Environmental and Social Impact Assessment Report

Yaoure Gold Project, Côte d'Ivoire

Submitted to

Perseus Yaoure SARL

Submitted By

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Report Issue Form

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0 NON-TECHNICAL SUMMARY

0.1 Project Description

0.1.1 Project Proponent

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0.1.3 Location

The Yaoure Gold Project (the Project) is located in the Bouaflé Prefecture of the Marahoué Region in Côte d'Ivoire. The Project is approximately 40 km northwest of the political capital Yamoussoukro, 260 km northwest of the commercial capital Abidjan and 25 km from the regional capital Bouaflé.

The mine is located approximately 6 km west from Lake Kossou and the associated hydro-power station. The Project location is indicated in Figure 0-1 and Figure 0-2.

The Project is an expansion of an existing gold mining operation that has been operating since the 1980's. Apart from the open pit and heap leach facilities of former operators CMA and Cluff Gold, there is a widespread legacy of artisanal mining in the area. It is therefore important to understand from the outset that the Yaoure Project will be built and operated in a significantly degraded brownfield environment and not in a pristine environment. This is therefore an impact assessment looking at the net effect between the new operations and the impacts already caused by the historic operations. This fact is also reflected in this Environmental and Social Impact Assessment (ESIA) including the pre-Project baseline studies.

It is also important to note that the original ESIA was based on preliminary information provided by Perseus in April 2015 from the Pre-Faisability Study. This updated ESIA is based on information provided by Perseus in January 2018 following the completion of a definitive faisability study. Therefore, the new information requires the ESIA to be updated so that themitigation measures are ensured of being relevant and appropriate.

Figure 0-1 Location of the Yaoure Project in Côte d'Ivoire

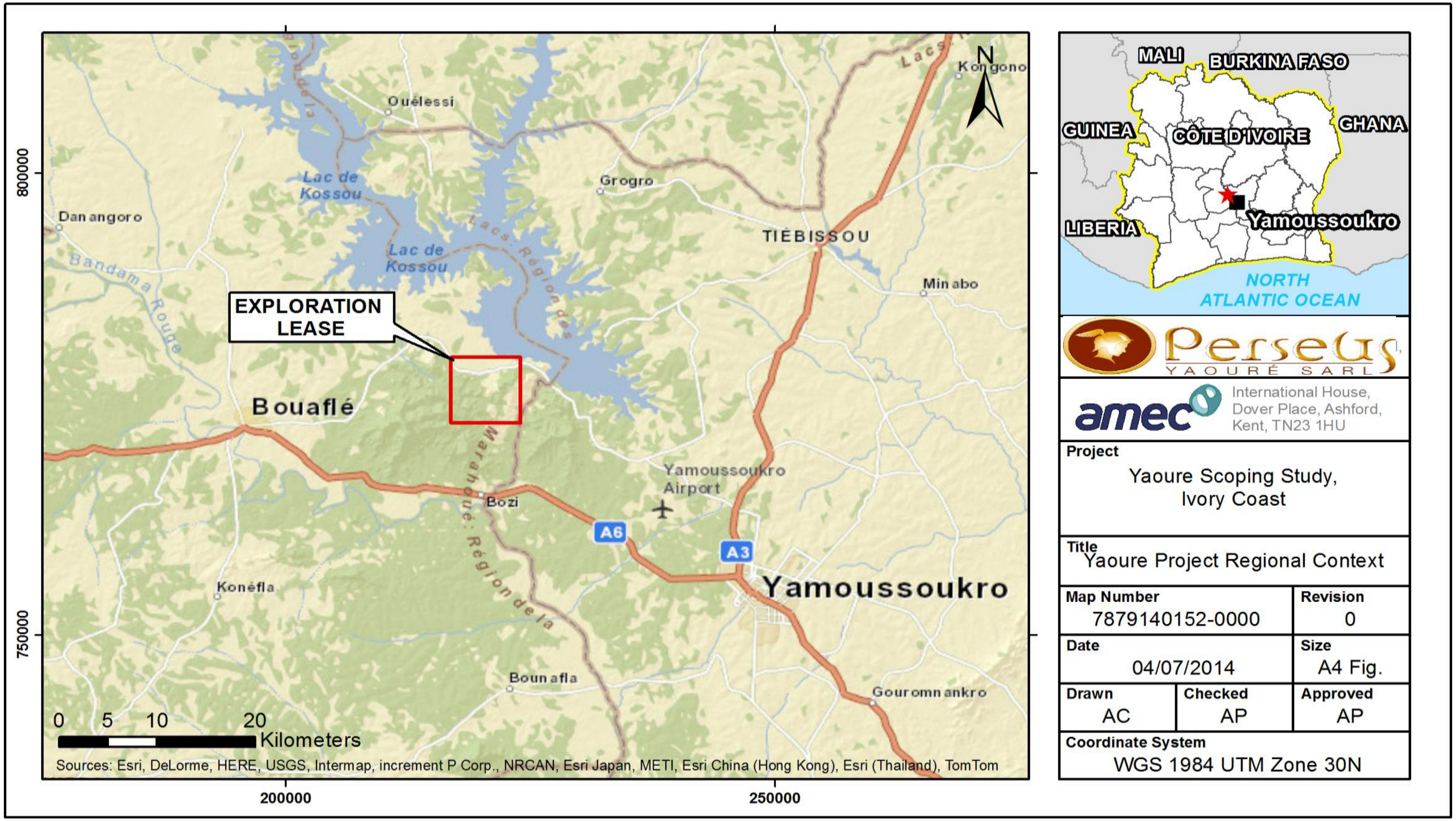
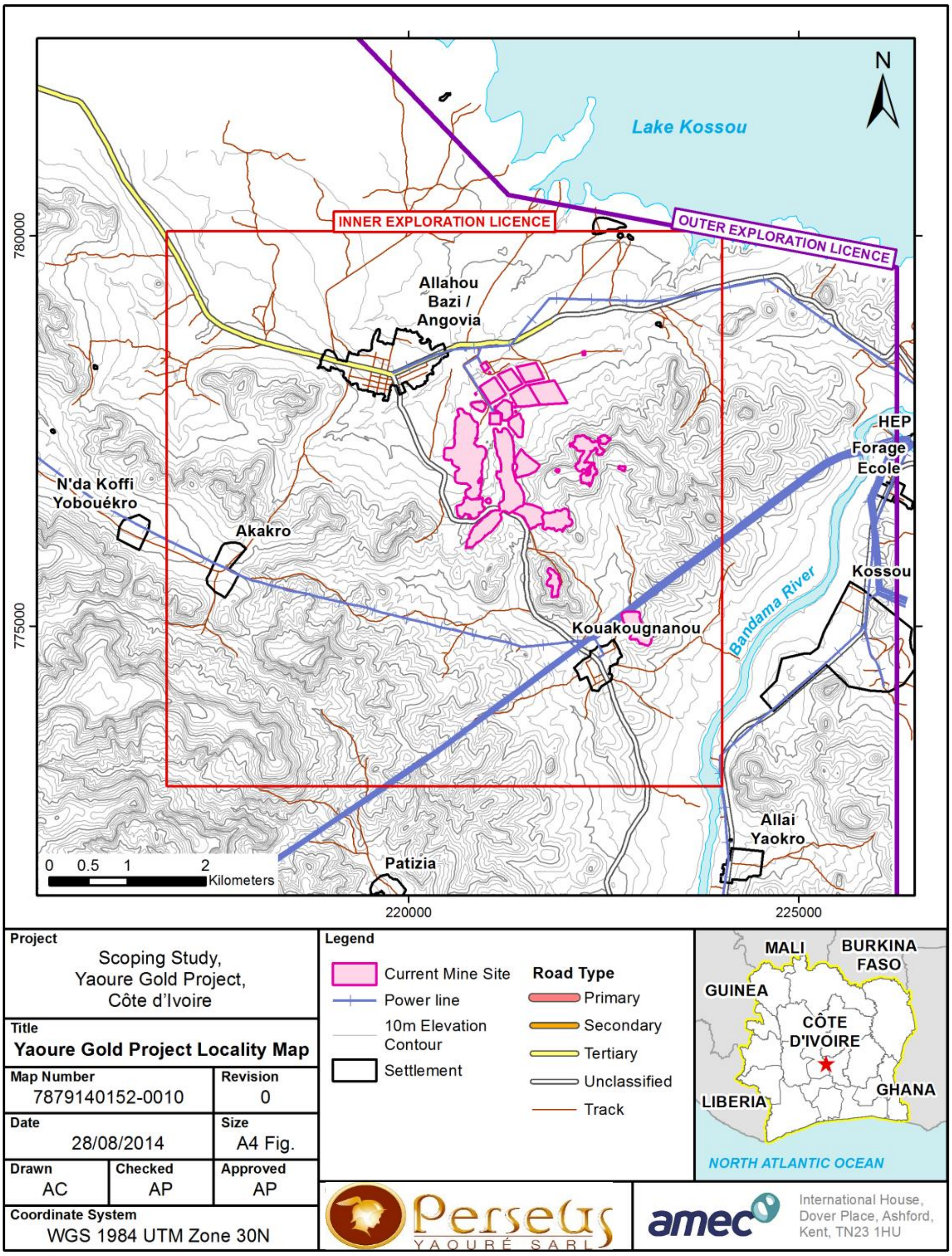


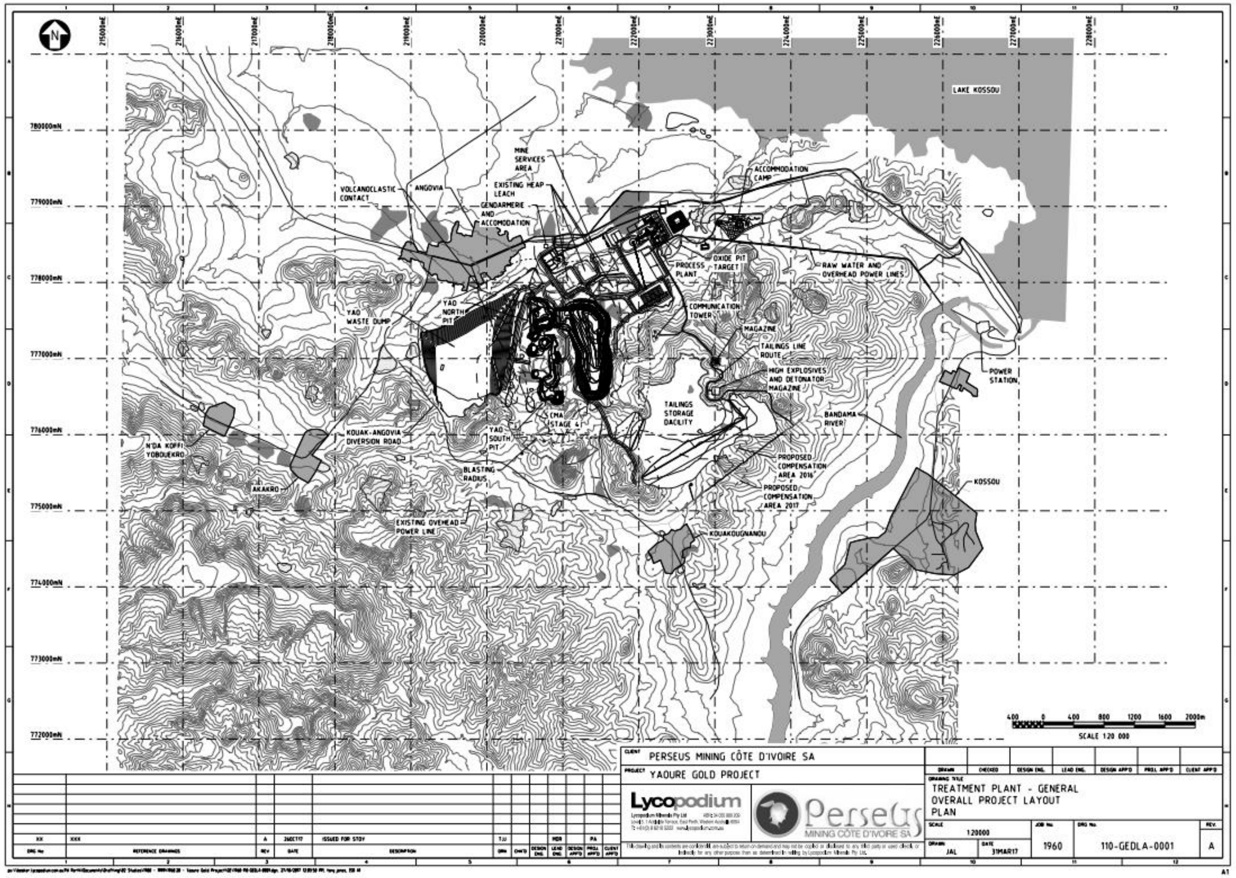
Figure 0-2 Yaoure Project Location (detailed)



0.1.4 Project Layout

A preliminary layout of the open pit, waste facilities and other mining infrastructure is provided in Figure 0-3. A map with larger format and higher resolution can be found in **Error! Reference source not found.**. It should be noted that the locations and footprints used throughout this Report are based on information received from Perseus in February 2018. Minor changes that do not affect the validity of the assessment and conclusions of this Report are expected with further project development.

Figure 0-3 Preliminary site layout (Higher resolution and larger format see Error! Reference source not found.**)**



From the preliminary layout, the following surface areas have been calculated:

Table 0-1 Footprints of project infrastructure elements (rounded)

Infrastructure element	Area (ha)
Camp	9
Plant & Admin Office Area	43.5
Waste Rock Dump	147
Recycling and Waste Disposal	0.5
TSF Pond	125
TSF Embankment/s	72
Water Storage Dam	9
Pit	50
ROM Pad & Stockpile	27
Haul Roads	25
Other Site Roads	5
Perimeter Fence	5
New Workshop (MSA)	10
Water Line Corridor – Plant to TSF	3.5
Gendarme Accommodation	0.5
HV Powerline Corridor	6.5
Magazine Area	2
Total footprint	**540.5**

* It should be noted that soil stockpile areas will be located in close proximity to extractive waste management facilities (WRD, TSF), and their footprint (assuming 0.2 m stripping depth and 5 m height of stockpiles and including the existing soil stockpiles of 100,000 m³ from previous operations) will be very small compared with the WRD and TSF footprints of 344 ha. This is within the accuracy of footprints at this Project development stage.

0.1.5 Mining Parameters

The pit size that is being considered in this ESIA is optimised for a gold price of US$ 1200 per ounce. The open pit will be mined at an average rate of 25Mtpa (ore and waste rock), of which ore is mined at an average rate of 4.5 Mtpa. The maximum mining rate will be 30 Mtpa. The mining rate of waste rock will drop off towards the end of the mine life (estimated 6 years). Over the operational life of the mine, a total of 162 Mt rock will be mined, of which 137 Mt are waste rock and 25 Mt are ore. The strip ratio, i.e., the ratio of waste rock to ore, is 5.4:1 The average ore grade (gold content of the ore) is 1.8 g/t.

The last year of mining operation will be year 6), and after that only stockpiled ore will be processed.

The maximum depth of the open pits will be 200 m below surface level.

Blasting will take place no more than once per day, at the same time of the day (approximately 4 pm during shift change).

At the present stage of Project development, the following information on the major vehicles and mining equipment is available however it is subject to change:

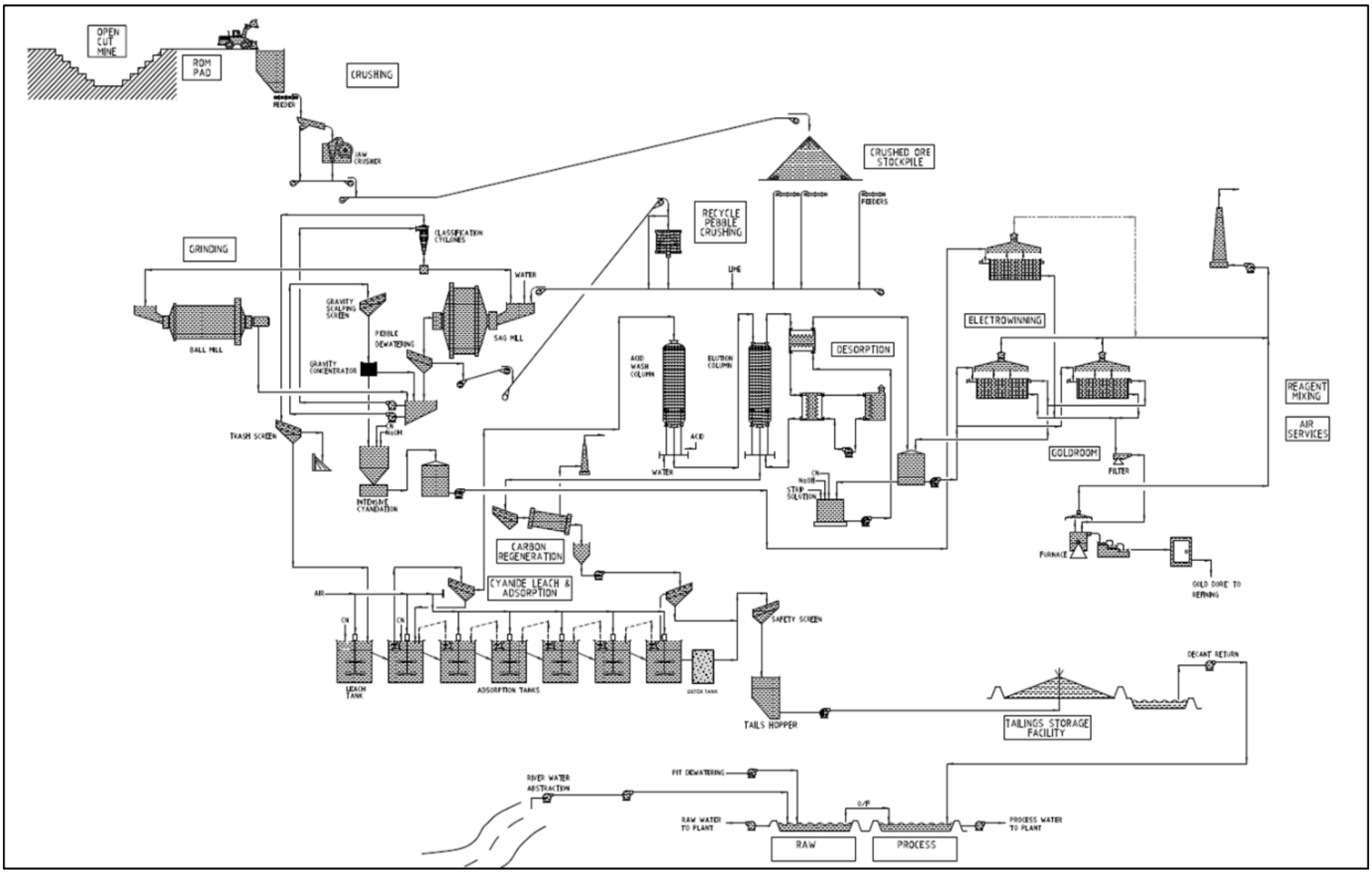
Table 0-2 Major mining equipment (preliminary)

Number Required	Equipment	Description	Make	Model
4	Primary Shovel	22 m³ electric hydraulic face shovel	CAT	6040E
2	Primary Loader	10-12 m³ Front end loader	CAT	992
4	Primary Track Dozer	610 hp 19 m³ track dozer	Komatsu	D375A-6R
3	Water Truck	HD785 Chassis with 75 m³ tank	Komatsu	HD785
34	Primary Truck	130-150 t Truck	Caterpillar	785C

0.1.6 Ore Processing

There are two types of ore mined: oxide and sulphide ore. Both oxide and sulphide material will be crushed and milled to a fine grain size so that the gold becomes better accessible to chemical leaching reagents, and then leached in the process plant using a standard cyanide leaching process. This is followed by an absorption stage where the gold is separated from the process liquors, elution, electrowinning and smelting. The final product is doré. A simplified process flow sheet is shown in Figure 0-4.

Figure 0-4 Simplified flow sheet of the Yaoure process plant



The plant will be designed according to the standards of the Cyanide Code (International Cyanide Management Institute, ICMI) where possible which defines international best practice of the gold industry to protect people and the environment.

0.1.7 Extractive Waste Management Facilities

The total amount of 137 Mt of waste rock will be deposited on one waste rock dump (WRD).

The Waste Rock Dump will consist of waste rock which will be profiled and vegetated, preferable starting from the outside first, to screen the village from noise and dust generated at the open pit and waste rock dumping operations.

Ttailings (solids) will need to be managed so that they are safely contained and the environment is protected. The tailings management facility (TSF) will cover an area of approximately 197 ha. The tailings slurry will be pumped through a pipeline to the TSF and deposited there using a system of pipes distributed around the tailings pond, called "spigots". Water will be recirculated back to the process plant using a skid mounted pump that will be gradually retracted as tailings deposition progresses.

The tailings embankment will be designed as a downstream dam, which is considered the safest form of embankment design.

The base of the TSF impoundment will be compacted, and incorporate perforated drainage pipes, so that pore water can be collected and managed. This will further reduce the risk of groundwater contamination.

0.1.8 Soil Management

Prior to placing waste rock, building the TSF or infrastructure, soil will generally be stripped and stockpiled so that it is available for environmental rehabilitation of the mine site.

Soil storage areas will be located in non-sensitive areas close to disturbed areas and waste facilities and will be protected against vehicle movements and erosion so that the soil is readily available for later closure and rehabilitation works, ensuring low costs through long transport distances and reduced risk of soil deterioration.

A separate Soil Management Plan has been developed that will ensure that best practice in soil management is followed throughout the entire life of the Project from construction to closure and rehabilitation.

0.1.9 Water Intake and Discharge

Water will be sourced, from pit dewatering and recycled process water that includes precipitation on the project footprint, most notably on the TSF area. As a last resort, should additional water be required it will be sourced from the Bandama River.

The Project aims at minimising the use of freshwater and the discharge of impacted water.

If water must be discharged, it will comply with the requirements of the standards of Côte d'Ivoire and where national standards do not provide limits or guidance, with international standards and recommendations such as the IFC EHS Guidance for the Mining Industry (2007).

A separate Water Management Plan has been developed that will ensure that best practice in water management is followed.

0.1.10 Energy Requirements

The Yaoure Project will require electric power for the plant and most of the infrastructure, and diesel for the mining equipment (trucks).

Electric power requirements will be approximately 40 MW that will hopefully be sourced from the power station at Kossou barrage. The Kossou power station is connected to the national power grid of Côte d'Ivoire. Overhead power lines from the Kossou power station to the Yaroure site will be aligned in the existing corridors of overhead lines/pylons. Additional transformers may be installed at the Kossou station. Based on information received from Perseus the Compagnie Ivorienne d'Electricité (CIE) taking 40 MW from the existing supply system will not affect supplies to any other communities.

Diesel consumption is estimated to be less than 1,500 m^3 per month, which results in no more than 80 fuel trucks (20 m^3) per month that will be delivered to site.

0.1.11 Roads

Construction Roads:

For initial and ongoing construction of the Yaoure Gold Project, heavy freight vehicles will have to use public roads. In order to ensure community health, safety and security, appropriate traffic regulation measures will be in place.

A separate Community Health, Safety and Security Plan has been developed that will ensure that road traffic risks are kept to a minimum.

Haul Roads:

Haul roads are assumed to be 25 m wide, but this is dependent on the mine fleet.

All roads will have a compacted and graded surface, no additional cover such as tarmac or gravel is planned at this stage.

Access Road:

The existing access roads will be used to gain access to the Project.

Public Roads:

The existing road from Kouakougnanou to Angovia will be realigned around the Project site. The new road will have a more gentle grade and eliminate the blind ridge in the existing one, thus it will be safer and more convenient to use by the local population.

0.1.12 Project Closure and Rehabilitations

As a guiding principle, Perseus is committed to sustainable closure and rehabilitation of the Project at the end of its life. Progressive ("concurrent") rehabilitation will keep the environmental liabilities to the technically and economically possible minimum at any time during the operation phase.

All mine infrastructure (plant, etc.) will be removed, as required under the legislation of Côte d'Ivoire, and the affected areas will be graded and revegetated. Possible exceptions that would have to be discussed with the local communities and the competent authorities include buildings that can be used by the community or the government after closure and rehabilitation of the Project site.

As stated above, the Project is an expansion of the existing dormant operation. It will integrate part of the existing mine infrastructure (e.g., heap leach installations and heap leach pads) and "encapsulate" them by new mining infrastructure and waste rock dumps, which will be rehabilitated at the end of the Yaoure Project or process the heap leach material so that they no longer exist.

Roads will be either rehabilitated or kept open for continued community use if so required by the Government.

In the open pit, groundwater will rebound and form a lake. Based on geochemical test results carried out with waste rock, metal leachability and formation of acid rock drainage (ARD) are not expected to be problems. Therefore, water management of the pit lake post-closure is not anticipated.

Safety berms will be erected along the pit perimeter to prevent access and minimise safety risks.

Waste rock dumps will be geotechnically stable during the operational life of the mine. They will be further reshaped and graded where necessary to blend into the environment and further improve long-term stability, covered and revegetated to minimise erosion and to ensure that similar slope angles blend well into the surrounding landscape and do not represent a pollution risk or a visual nuisance. Existing water diversion channels will remain in place, additional erosion protection channels will be built where required.

The current closure concept for the TSF consists of contouring the tailings beach through a strategic deposition plan in the last few years of the mine life, followed by placing a 0.2 m thick layer of topsoil and revegetation.

Water storage ponds and settling lagoons will be removed and the surface levelled and covered with soil and vegetation, unless Government and communities request that the ponds remain in place for continued use and economic community development, e.g., as fish breeding ponds.

Environmental monitoring will continue during the closure and rehabilitation phase, and into the post-closure phase to demonstrate compliance with legal requirements and identify area where corrective action is required (e.g., erosion processes that must be controlled, water management etc.).

Social and socio-economic consequences of mine closure inevitably include retrenchment and loss of livelihoods. However, during the operation period, Perseus Yaoure will strive to develop the socio-economic capabilities of the Angovia community and the wider area so that negative consequences of mine closure are mitigated as far as possible. This may include, but not be limited to, skills development programmes for Perseus employees to improve their post-Project employability, or local purchasing programmes of Perseus to help local businesses develop sustainably and develop business outside the Project. Details of the socio-economic mitigation strategy will be developed closer towards the end of the mine life.

A separate Conceptual Closure and Rehabilitation Plan has been developed that describes the closure and environmental rehabilitation strategy in more detail. The Conceptual Closure Plan will be further developed during the operational phase of the mine.

0.1.13 Time Frame of the Project

The expected duration of the various phases of the Project life cycle is summarised in

Table 0-3. Note that the duration of each phase is indicative only and is subject to further refinement as Project development progresses.

Table 0-3 Expected duration of Project life cycle phases

Phase	Duration
Construction and commissioning	18 months
Operation	6 years
Closure	3 years*
Post-closure	TBD

*Assuming that a significant part of closure works will have been completed as part of the operations (concurrent rehabilitation) and placement of the tailings cover can begin soon after the end of tailings disposal.

0.1.14 Land acquisition

Perseus will need to acquire 1,109 ha of Project footprint during the pre-construction and construction phases. It is estimated that roughly 15% of the land in the study area is agricultural land. Impacts will occur before the construction machinery is mobilised and will endure for the life of the Project. It is anticipated that limited physical displacement will take place as a result of impacts upon residential land or structures. Similarly, it is expected that no significant temporary or permanent limitations/restrictions of land use will occur outside the project footprint.

Artisanal mining sites located within the Project footprint will also be affected by economic displacement impacts. However, it must be noted that artisanal mining activities in the Project area have recently significantly reduced as a result of Government action to curb illegal mining activities.

The land acquisition process follows on from the current year-to-year lease agreements. To date, Perseus has secured some 385 ha of land under year-to-year lease agreements with the relevant customary landholders.

A separate Framework Livelihood Restoration Plan has been developed that contains more details on Perseus's strategy to compensate affected households during the land acquisition process.

0.1.15 Employment Opportunities and Community Development

During operation, it is currently assumed that approximately 250 people will find permanent employment at the Project. However, contractors and temporary jobs will add to this number and increase the overall employment opportunities that come with the Project.

The required skills will be matched against the availability of skills in the Project area, so that recruiting and employment from the Project area is maximised. As the Project endeavours to be compliant with the International Finance Corporation's Performance

Standards (IFC PS, 2012), Performance Standard 2 (Labour and Working Conditions) will be followed.

A Recruitment Plan will be implemented by Perseus. A separate Community Development Plan has been developed as part of this ESIA.

0.2 Main Impacts and Management/Mitigation Measures

The following sub-sections summarise the findings of the environmental and social impact assessment. In the assessment it is assumed that the environmental/social mitigation and management measures are implemented, i.e., the significance ranking describes the post-mitigation impacts.

0.2.1 Water

Surface water

The Project site is mainly drained by perennial and non-perennial tributaries of the Bandama River. Many stream courses are ephemeral, only flowing during one of the wet seasons.

Drainage from the major part of the area of the proposed open pits flows northwards into Kossou Lake. The extreme southern edge of the open pit is drained southwards into a separate tributary catchment which flows into the Bandama (Blanc) River south of Kossou Dam.

Surface watercourses are used considerably by local communities for drinking water supplies, irrigation, washing, etc., albeit many of the watercourses around the project site are ephemeral and have not been observed to flow during the monitoring programme up to the cut-off date.

The majority of potential surface water impacts will be managed and mitigated through infrastructure design, the Emergency Preparedness and Response Plan and the Mine Water Management Plan.

During the construction phase, the following principal mitigation measures will be implemented:

- Vegetation and top soil will be stripped at the commencement of construction works;
- Hydrocarbon storage areas with bunded bays and fuelling stations with sufficient bunding and retention structures will be constructed. The ground will be an impermeable surface, hydrocarbon traps and a fuel station drainage system will be in place for water treatment prior to release to the surface water runoff system;

- All equipment using hydraulic fluid (oil, fuel, etc.), will be subject to a preventative maintenance programme;
- Where possible, uncontaminated (non-contact) water will be kept separate from potentially contaminated (contact) water;
- Runoff water with a large sediment load will be captured and directed via berms or ditches towards sediment control structures. These may comprise a series of settlement ponds with additional integrated filtration measures where required; and
- Roads will be profiled to minimise water accumulation on the road surface.

During the operation phase, the following principal mitigation measures will be implemented:

- Solids settled in the sedimentation ponds and drainage channels contening solids particulates will be removed during the dry season;
- Erosion protection/control measures will be put in place and storm water management infrastructure will be monitored and maintained regularly;
- Tailing dams checking will be done at regular intervals within any surface water resource network;
- Silt traps will be installed for maintenance purposes along drainage channels;
- Hydrocarbon traps will be regularly checked. Residues from the hydrocarbon traps will be stored and managed according to Perseus's waste management procedure;
- All equipment using hydraulic fluid (oil, fuel, etc), will be subject to a preventative maintenance programme;
- Mine water will be pumped from the open pit to settlement ponds, if water quality doesn't meet the rejection standards, to be utilised for dust suppression or transferred to the raw water pond for reuse in the plant where supply shortfalls are anticipated. Excess produced water will be discharged to the environment in accordance with IFC effluent water and water quality standards of Côte d'Ivoire;
- WRD surface will be contoured and profiled, to be stable and resistant to long term erosion;
- The runoff from WRD, where possible, will be collected in a drainage system and discharged to environment after passing through sediment traps and where IFC effluent and water quality standards of Côte d'Ivoire are met;
- Perimeter storm drains will divert surface water runoff.

- At the Plant, operations will be done in a bunded area and collected water will be pumped back to the Plant. Contaminated water will be treated in a settlement basin and discharged into the environment in conformity with IFC effluent water quality performance standards of IFC and Côte d'Ivoire;
- The quality and volume of any discharge from the tailings storage facility will be regularly controlled;
- The return water pipeline will be tested for leaks and weaknesses zones prior to being placed into operation. Leak detection inspections will be conducted along the entire pipeline on a regular basis; and
- Roads will be maintained regularly. Maintenance will include systematic emptying of accumulated sediments from the culverts and silt traps of the dams.

During the closure phase, the following principal mitigation measures will be implemented:

- Water in TSF pond will be drained prior to closure to reduce the potential for overtopping and erosion of the embankments. If the supernatant water does not meet discharge standards, it will be treated prior to discharge into the environment;
- WRD and TSF will be covered with stockpiled soil and vegetated to provide stability against erosion;
- Profiling and contouring will be used to minimise ponding on the TSF surface;
- Diverting and flooding evacuators will be put in place to minimise potential erosion of the top soil from runoff;
- Discharge waters will continue to be treated during the closure period where IFC standards and water quality standards of Côte d'Ivoire are not met. Active systems will be transferred to passive systems following appropriate trial periods.

The majority of surface water samples are Mg-Ca-HCO3 water type and the majority of groundwater samples are Ca-Mg-HCO3 water type. Apart from detectable (but not significant in terms of potable water quality) concentrations of arsenic which are likely to be geology related, water quality is generally good, albeit not many surface water samples have been taken to date due to the absence of flow of the tributaries. Mine surface water management operating essentially as a closed circuit, so, it is not expected to impact on chemical quality of the surrounding natural surface water systems.

Mitigation measures are expected to reduce impacts to at least low or even negligible levels.

Ground water

There are two main aquifer types associated with the Project:

- Shallow Weathered Aquifers mainly associated with weathered sedimentary rock (schist) and transitions of granite. The permeability is low and porosity is weak as a result of relatively high clay content. Most of the villages take their groundwater from this aquifer. Due to the shallow nature of the aquifer it is at risk of pollution.
- Fractured Aquifers are deeper and associated with geological fractures and rock fissurations. The porosity is very low. Permeability is high in areas where fissuring and fracturing are dense. The water table varies between 40 m to 60 m below surface.

On the basis of information available after the completion of the DFS, the preliminary groundwater model indicated total annual long-term inputs of 1,423,000 m^3 (year 4) and up to 2,440,000 m^3 (year 6).

It is possible that extraction wells in a tightly fissured rock aquifer such as the one present may not be able to produce raw water withdrawal rates required for the treatment plant (337.3 m^3 / hr for overall site) which includes a total average of 7.3 t / hour of bore water to meet the site's potable water needs requirements. In addition, the total drying of pit water during excavation will not be possible. Such an assumption should be considered as part of the mine plan.

During the construction phase, the following principal mitigation measures will be implemented:

- Dewatering will be necessary to make the working environment safe and dry for earthworks and excavations. Groundwater levels and quality will be monitored during the construction phase according to the Mine Water Management Plan;
- Groundwater contamination could occur through accidental spillage of hazardous or toxic materials either through handling (i.e., movement, maintenance, refuelling of site and plant vehicles) or from storage (i.e., oils, fuels, solvents, etc). Standard operating procedures for handling of hydrocarbons and chemicals are to be followed. Any spills will be contained and remediated as soon as possible and records kept. All fuels and lubricants will be kept in bunded areas/containers. The significance of the impact after these mitigation measures is Low;
- A greatest number of personnel will be on site during the construction phase and will put pressure on water supply and water disposal at the construction camp and employee facilities. Potential contamination of groundwater could occur through discharge of untreated sewage. All sewage in the construction camp will be collected and treated to IFC standards prior to discharge. The residual significance of impact is Low.

During the operation phase, the following principal mitigation measures will be implemented:

- During mine operations the most significant impact to groundwater will be due to a reduction in groundwater levels associated with dewatering of the open pit. In order to provide some quantitative basis for groundwater impact evaluation, a preliminary groundwater model has been developed. Preliminary groundwater model predictions indicate that the extent of drawdown in the bedrock could be tens of metres at the closest village wells. If realised, this would be a major impact and of high significance. The reduction in groundwater levels could result in reduced groundwater baseflow of watercourses within the extent of drawdown with associated potential impacts to groundwater users. However, owing to the low hydraulic conductivity the predicted cones of depression are relatively close to the pit and around the abstraction bores but the impact on groundwater levels does extend to the surrounding villages. Direct impact of groundwater level reduction on village boreholes would be mitigated by compensation water from auther water source (i.e a deeper water bore). The latter could provide a legacy positive impact for the project for local communities. The residual significance of impact to groundwater associated with open pit dewatering and community water supplies is Low.
- Monitoring of open pit inflows and groundwater levels will be conducted to ascertain the extent and rate of drawdown propagation to enable update of the conceptual hydrogeological understanding and groundwater flow modelling to refine predictions. Compensation to watercourses will be achieved through discharge of dewatering water at appropriate locations and diversion of runoff water.
- Sediment traps will be used to ensure settlement of entrained particulates prior to discharge. Water quality measurements will be made at the discharging point. The residual significance of impact to groundwater associated with open pit dewatering and water discharge is Low.
- Groundwater quality monitoring will be conducted around and downstream of WRD, TSF and stockpiles. Collected seepage will be discharged to the environment following appropriate treatment. The residual significance is Low.
- Groundwater monitoring points downstream of TSF will be regularly measured for level and quality to ascertain systematic change from baseline conditions and assess potential impacts on the receptors. The significance of impact after mitigation remains Low subject to further testing of the tailings material.
- Excess water discharged from TSF will be treated as necessary to ensure compliance with IFC water quality standards and Côte d'Ivoire legal requirements. Significance of impact after mitigation is Negligible.

- To minimise infiltration of contaminated water to groundwater, contact surface water will be diverted through a system of channels and berms towards lined sumps to be contained and treated before discharging. Discharge water quality and downstream groundwater levels and quality will be monitored. The significance of impact after mitigation is Low.
- Leak detection equipment will be used for the TSF return water pipeline and the plant site equipped with an appropriate leak response system. The significance of impact after mitigation is Low.

During the closure phase, the following principal mitigation measures will be implemented:

- Monitoring of groundwater level and quality will continue during the closure period to identify any impacts and develop a management strategy where required. The residual impact significance remains Low.
- Seepage from TSF will gradually decrease as the tailings consolidate and hydraulic conductivity of materials reduces. Run-off recharge to TSF will be minimised by covering the facility with material. Groundwater quality and level will continue to be measured around and downstream of TSF during the closure period. The residual impact significance remains Low.
- Discharge waters will continue to be treated during the closure period in order to comply with IFC water and effluent standards and Côte d'Ivoire effluent discharging limits. Active systems will be transferred to passive systems following appropriate trial periods. With these measures, the residual significance of impact to groundwater from discharge water seepage is consequently considered Negligible.
- Appropriate standard operating procedures (SOPs) and best practice will be followed during removal and disposal of hazardous or toxic materials storage facilities and decommissioning of structures/facilities. Any spills will be contained and remediated as soon as possible, and records kept. The residual significance to groundwater is considered Low.

In addition to assessing the impacts of pit dewatering, consideration has also been given to potential impacts on groundwater quality due to seepage from the TSF and waste dumps. On the basis of the preliminary transport model leakage of arsenic bearing leachate into the aquifer is not predicted to cause a water quality problem at downgradient wells, especially when coupled with the conservative assumptions regarding groundwater flow and solute transport.

Water management

The principal water management objectives as far as possible at this stage are to:

- Operate TSF as close as possible to a zero-discharge facility; and
- Minimise the requirement for external make-up water.

The former is a challenging task in the climate conditions pertaining to the site. This will require the diversion of as much water as possible during wet periods, together with the maximum use of TSF recycle to the process plant. In extreme conditions, pumping of supernatant water back over the dry areas may be required to maximise the use of available evaporative processes.

The latter is achieved by maximising TSF recycling wherever possible and making use of pit groundwater inflows and borehole dewatering arisings if TSF recycle water only partially meets process requirements. Water quality is expected to be benign, enabling this to take place without treatment other than settling of suspended solids with respect to water pumped from the open pit.

In wet conditions, excess water can build up on TSF and so recycle to the process plant needs to be the maximum and all diversions need to be active. In average conditions diversion channels may need to be switched in and out depending on circumstances. In dry conditions there may be a deficit in TSF, even if all diversions are switched off to enable the catchment water to report to TSF; if there is insufficient water in TSF to fulfil all the process needs, then it will need to be increased with arisings from dewatering. At present it is considered that this will always be sufficient, so there would be no need for external make-up water (even though the option to abstract from Bandama River is included in the design).

Further details of the Water Balance Model are contained in the Mine Water Management Plan.

Water supplies

Current water balance modeling indicates that below average climate conditions, compensating water needs will be required. Therefore, the design includes an emergency storage of Bandama River to allow water to be taken if necessary.

The processing water and camp potable water supplies will come from the results of pit dewatering water via an appropriate water treatment plant (s). Effluent will be treated in a water treatment plant before being discharged into the environment according to Ivorian regulations.

It is not expected that surface water management at the operational mine, operating essentially in a closed circuit, will impact on surrounding natural surface water systems.

0.2.2 Soil

In general, the soil as a resource is considered a sensitive component as this is the stabilising material through which trees and animals sustain life, where water is stored and utilised, and where the rooting of vegetation is able to control erosion and to reduce loss of surface water.

The potential impact and footprint area is relatively large in comparison with the size of the area to be mined, with TSF and WRD covering very large areas of land, while the support infrastructure and associated activities are relatively wide spread across the Project area.

The Project will impact some of the more sensitive sites that are associated with shallow or wet based soil forms.

Before the construction phase, the topsoil will be carefully stripped and stored at a height of up to 6 m, in order to dispose of sufficient soil for closure and rehabilitation at the end of life of the mine. Land storage areas will be protected from vehicular traffic. Heaps of topsoil will also be vegetated and covered to minimize erosion.

Precautionary measures will be taken to minimise the risk of accidental spillages of hazardous materials. This will reduce the following potential impacts as far as technically and economically possible:

- Loss of the soil resource due to change in land use and to removal of the resource from the existing system;
- Sterilisation of soils due to the management of waste rock and tailings;
- Loss of the soil resource due to the erosion (by wind and water) of unprotected materials (removal of vegetative cover and/or topsoil);
- Contamination of the resource due to spillage of raw materials and the possibility of spillage of reagents transported to the site and used in the process;
- Contamination of stored or in-situ materials due to impacts of dust or dirty water from the project area and raod traffic; and
- Loss of the soil utilisation potential due to the disturbance of the soils and potential loss of nutrient content through infiltration and de-nitrification of the materials during their storage or due to disturbance of the materials.

The operational phase is a period where management of stockpiles of soil and the impacts of contamination of the resource need to be considered and implemented as part of the daily housekeeping. Rehabilitation will start during the operation phase (concurrent rehabilitation) to minimise the environmental impacts as far as possible.

The use of mine water for road wetting, dust suppression and irrigation will need to be considered carefully if the impacts of contamination of the stored soils and surrounding (in-situ) materials are to be managed.

With effective implementation of all mitigation measures, the significance of residual impacts on soil resources will be Moderate to Low.

0.2.3 Biodiversity

Given the high level of habitat disturbance in the area resulting from historical and current artisanal, as well as commercial mining activities, impacts are not expected to affect significantly local flora and fauna populations.

The following potential impacts related to the proposed Project activities have been identified:

- Habitat loss – Direct habitat loss as a result of vegetation clearance will happen, which may lead to the mortality of fauna during and after land clearance;
- Habitat fragmentation – Habitat fragmentation resulting from vegetation clearance and infrastructure construction will create potential barriers that may interfere with wildlife movement. This can lead for example to a potential genetic damage;
- Vehicle collision leading to injury or mortality – Direct mortality or injuries to wildlife can result from collision with Project vehicles due to an increase in road traffic during the life of the Project;
- Hydrological impacts – Hydrological impacts include diversion of small streams, discharge of water into the environment and/or an increase in sediment load due to erosion that may affect or change water flow of surrounding surface water. This may lead to changes in freshwater ecology, and potential decline in populations of species reliant on freshwater habitats;
- Chemical water and soil pollution – Potential impacts on chemical water quality can arise from site run-off, site discharges (although expected to be infrequent) and unplanned events such as accidental spills of process reagents/chemicals and non-hazardous and hazardous materials from the Project site;
- Habitat degradation – Habitat degradation can come from various sources such as noise, vibrations, air pollutants and dust, and general human disturbance. These can adversely affect fauna species, for example by leading to avoidance of noisy areas, leading to a change in behaviour, incurring stress, etc;
- Human exodus and in-migration – An increase in the influx of people coming to the area looking for job, project staff and families, and service providers can increase the pressure on local resources such as fuel (e.g. firewood) and food (e.g. bushmeat) for direct consumption or for commercialisation, and can also result in habitat loss from conversion of natural areas to cultivated land;

- Invasive species and pathogens – Invasive species may be introduced in the environment through the movement of Project vehicles. Invasive species can out-compete native species and lead to changes in species composition and degradation of habitat. Changes in ecosystem composition and habitat structure may lead to a change in disease transmission process and/or increase the likelihood of pathogen transmission to wildlife populations.

All impacts are expected to occur throughout the three phases of the Project life (Construction, Operation, Closure), except for habitat loss which is restricted to the construction and operation phases.

Baseline surveys were conducted on six groups based on the strategic pre-scoping: birds, amphibians and reptiles, flora, freshwater biodiversity groups, large mammals, small mammals. Only one Endangered species, a fish species *Mormyrus subundulatus*, was identified whitin the Project area. These surveys provided baseline levels against which to monitor potential impacts of Project activities.

Several mitigation measures will be implemented by Perseus to reduce the magnitude of impacts and if these are properly implemented, then residual impacts are expected to be at the most of Moderate significance.

Ongoing monitoring will ensure that mitigation measures are sufficient. It is particularly important to conduct the monitoring of water quality, as this has been highlighted as the most important resource for the local community, and the freshwater ecosystem is the most sensitive to potential water pollution, contamination and/or flow change.

0.2.4 Ecosystem Services

Ecosystem services are benefits that ecosystems provide to people, businesses, plants and animals as well as transporting materials and energy around the planet. Ecosystem Services are classified into four categories:

- Provisioning Services – these are goods or products obtained from ecosystems, such as food, water, timber and other products from plants such as fibre;
- Regulating Services – these include benefits obtained from an ecosystem's control of natural processes, such as climate regulation, disease control, erosion prevention, water flow regulation, and protection from natural hazards;
- Cultural Services – are the non-material benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment; and
- Supporting Services – are the natural processes such as soil formation, nutrient cycling and primary productivity that maintain other ecosystem services.

A list of priority Ecosystem Services were identified to be utilised by the local communities, some of which are also of relevance to the Project. The significance of impacts was assessed for each Ecosystem Service before and after mitigation measures are implemented.

Provisioning services

- Food – Collecting wild fruits;
- Food - Hunting;
- Food - Fishing;
- Food - Agriculture;
- Fuel - Firewood;
- Freshwater.
- Natural medicine – Medicinal plants;
- Biological raw materials - Construction materials; and
- Abiotic raw materials - Mineral resources.

Regulating services

- Seed dispersal and pollination;
- Regulation of natural hazard - Forest cover;
- Erosion control;
- Pest control.

Cultural services

- Spiritual values – Sacred forests;
- Spiritual values – Cemeteries; and
- Educational and cultural heritage values - Archaeological artifacts; and
- Ecotourism.

Supporting services

- Nutrient cycling processes;
- Soil formation processes;
- Photosynthesis;
- Pollination

As questions relating to Ecosystem Services require a multi-disciplinary approach, mitigation measures applying to impacts on Ecosystem Services are discussed in the different ESIA chapters (e.g. Soil, Water and Biodiversity). If these mitigation measures are properly implemented, impact significance can be reduced to Major or a lower rating for most Ecosystem Services. Where full restoration is not possible, compensation or replacement services will be provided (e.g. cemeteries).

0.2.5 Noise/Vibration

The following receptors were chosen as being representative of the environs around the Yaoure Project:

- Southern fringe of Allahou-Bazi;
- Southern fringe of Angovia**;**
- Eastern fringe of Akakro;
- South western fringe of Allahou Port (Fishing Hamlet);
- Northern fringe of Kouakougnanou;
- Northern fringe of Kossou; and
- Western fringe of construction workers camp and operational mine camp.

The noise assessment has predicted noise levels to the above selected receptors for construction, operational and decommissioning activities from the Yaoure Project.

The predicted noise levels for construction and decommissioning activities have been shown to comply with the relevant noise limits under the legislation of Côte d'Ivoire and, for comparison, those derived from the IFC EHS Guidance (2007) and UK's BS5228-1:2009+A1:2014, even during the night-time. The effects due to these operations at all receptors, during the daytime, evening and night-time period were therefore considered to have an impact rating of "Low". The exception was the construction workers camp which did not comply with the criteria but due to its reduced receptor sensitivity this was not considered to be a significant potential impact.

The operational noise predictions have been undertaken using AMEC's proprietary noise modelling software, CadnaA. A 3D model of the area has been constructed which included the noise sources making up the particular activities under consideration as well as the receptor locations.

The predicted operational noise levels are generally all, within the daytime and evening criteria, compliant with CIAPOL standards and are also below the relevant IFC noise limits for daytime periods. When waste rock tipping activities on the closest extremities of the waste rock dumps are undertaken on the outer edges of the tips, there is potential for some evening and night-time criteria to be exceeded at certain receptors.

The adoption of a sequential approach to the construction of pit dump, involving the construction of an outer face behind which more unloading / loading would unfold. This is particularly important for the construction of night-time dumping at receptors in the local community. In addition, it is recommended that if nocturnal offloading activities are required, noise monitoring is conducted to determine compliance with the respective criteria of CIAPOL (Côte d'Ivoire Pollution Control Center - CIAPOL).

With the implementation of the recommended measures, the effects due to normal operations at all receptors, during the daytime, evening and night-time periods were therefore considered to have an impact rating of "Low".

Since all the calculations are based on worst case assumptions, it is considered that actual noise levels are likely to be even lower and therefore even further below the relevant noise limits.

A further reduction in the potential noise impact (albeit already low) may be achieved by implementing several measures which can be characterised as "good practice" to minimise noise disturbance at receptors. These are described in a separate Noise and Vibration Management Plan.

The Noise and Vibration Management and Monitoring Plan will enable confirmation of compliance with CIAPOL (and IFC EHS, UK standards for comparison) noise limits, any exceedances to be identified and additional mitigation to be included if appropriate at that time.

Due to the relatively large separation distances involved (>350 m) it is considered that construction/decommissioning vibration will not be an issue at the Yaoure Project even from the use of pneumatic hammers to break up concrete rafts during the decommissioning and closure phase.

0.2.6 Blasting Vibration

The main vibration producing activities at the Yaoure Project considered in the assessment were production blasting operations associated with waste and ore extraction.

The same receptors as those considered for the noise assessment were chosen as being representative of the vicinities of the Yaoure Project (see Section 0.2.5 above).

As more detailed information is not available at the current stage of Project development, the blasting vibration assessment used data collected on basalt quarries in the UK (stone with a similar hardness and density to the material to be blasted at Yaoure). The predicted Peak Particle Velocity (PPV) levels for both residential and infrastructure receptors from waste/ore body blasting activities were found to be, without exception, well within the relevant chosen blasting criteria. The effects due to these operations at all receptors, during the daytime period were therefore considered to have an impact rating of "Low".

No additional mitigation is considered necessary at this stage, since no significant blasting vibration effects have been identified. However, a further reduction in potential vibration impacts (albeit already low) may be achieved by implementing several measures which can be characterised as "good practice to minimise blast generated vibration disturbance at receptors". These are described in the Noise and Vibration Management Plan.

The Noise and Vibration Management and Control Plan will confirm compliance with the recommended blasting standards. Any overshoot will need to be identified and appropriate additional measures implemented as necessary, including the use of explosives that cause less vibration.

0.2.7 Air Quality

The potential air quality impacts associated with the Project that were considered in the assessment included:

- Human health and amenity effects associated with PM_{10} and dust generating operational site activities; and
- Human health and effects associated with emissions to air from the on-site plant and vehicles.

Twenty-five (25) receptors were chosen as being representative of the environs around the Yaoure Project.

The advanced dispersion model ADMS was used to perform an assessment of emissions from pollutants and fugitive dust releases from the on-site plant and machinery.

Operational activities at the Yaoure project site were found to result in a Moderate level of impact. Although impacts from the site are likely to be present for a period of 6 years, the project will not cause an irreversible air quality impact and pollutant concentrations should remain within the IFC Air Quality Guidelines (AQGs) for SO_2 and CO. NO_2, PM_{10} and $PM_{2.5}$ will remain within the EU AQSs. Project-related dust deposition levels will remain within the most stringent category (less than 250 $mg/m^2/day$) at all human receptors. The sensitivity level of the local receptors is Medium, therefore impacts without mitigation are predicted to have a medium level of significance.

Full implementation of best practice methods and mitigation measures to help minimise the emission and transport of dust and particulates beyond the site over the full duration of the Yaoure Project are considered to reduce the potential impact, thereby resulting in post-mitigation residual air quality impacts of Low significance.

Air quality impacts on nearby flora and fauna were scoped out from requiring detailed assessment through discussion with the biodiversity specialists. Nevertheless, a qualitative assessment has been undertaken that revealed no significant impacts on biodiversity receptors.

0.2.8 Traffic

An assessment of the environmental impacts as a result of traffic increases was undertaken. It was established that the effects of traffic increases on local communities, vulnerable road users and non-vulnerable users are Negligible.

No specific management measures have been identified. However, the traffic situation will be monitored in order to ensure the outcome of this assessment remains valid.

0.2.9 Socio-Economics

The socio-economic assessment has revealed the following categories of impacts:

- Economic and Employment Impacts;
- Displacement Impacts; and
- Population and Community Change Impacts.

Based on a detailed assessment of the significance of the impacts (being a function of the receptor sensitivity and impact magnitude) adequate enhancement and mitigation measures were developed that are discussed in the following for each impact category:

Economic and Employment Impacts include the following

- Payment of national and regional taxes;
- Employment opportunities at national, regional and local level; and
- Business opportunities at national, regional and local level.

Enhancement measures during the construction and operation phase include the following:

- Comply with EITI standards on financial reporting to ensure transparency of financial transfers to authorities of Côte d'Ivoire;
- Engage with national and local authorities to encourage cooperation in the governance system to maximise benefits for impacted communities from induced economic growth and payment of taxes;
- Priority of local hiring for unskilled positions, and hiring from a wider area in case of skills shortage;
- Compliance with IFC PS 2;
- Local preference given to local candidate with appropriate qualifications and experinces for Project needs;
- Employment procedures and conditions during construction will conform to international standards with respect to protection of human rights;

- All employment will be managed via Local Employment Offices. No employment will be offered directly at open pit sites or work areas;
- Positions advertised locally (radio, local employment offices, etc.);
- Set up a local recruitment committee with local government representatives if necessary, and nearby communities;
- Provide skills development programs for Project staff;
- Facilitate access for local employment for skilled positions;
- Support for local education initiatives;
- Study local professional skills and establish a database of local job seekers;
- Facilitate access to information on procurement to help local businesses remain competitive;
- Facilitate partnerships between regional finance and training providers and local businesses;
- Create local business development activities to support the creation of sustainable local businesses;
- Local business surveys and establishment of a Vetted Local Supplier Database;
- Employment practices and working conditions will conform to the requirements of IFC PS 2 (Labour and Working Conditions), the national Labour Code and International Labour Organisation (ILO) Standards;
- Provide workers with Personal Protective Equipment (PPE) for the eyes, nose and ears in areas at risk;
- Contractors and sub-contractors will commit to Perseus's strict Health, Safety, Labour and Environmental standards, to ensure that all people working for the Project are treated under the same minimal working conditions standards;
- Strict procedures will be adopted for hazard identification and risk assessment and for definition and implementation of appropriate mitigation measures to ensure a safe workplace. Relevant information will be communicated to all Project personnel;
- A comprehensive health and safety plan will be developed prior to commencement of any activities to ensure that workers are aware of the risks associated with activities; and
- Open pit machinery such as trucks and dozers will have ROPS, air-conditioned, dustproof and sound proof cabins to protect operators.

During the closure phase, some of the above benefits will be reduced. Specific mitigation and enhancement measures will need to be identified after a careful study of the socio-economic profile of the study area towards the end of operating phase. These measures could be skills upgrading programs for Perseus employees, with a view to improving their employability, or focusing on local services or value-added local products to help local businesses to develop sustainably and to develop their business outside the Project.

All post-enhancement impacts have been rated minor positive to major positive.

In general terms, during closure and rehabilitation, socio-economic impacts are expected to be of similar nature – but lesser significance – to those of the construction phase. Closure and rehabilitation activities will continue to generate socio-economic impacts on business and employment opportunities (positive), economic displacement/rehabilitation (positive) and population and community change (negative).

The de-commissioning of a mining project is likely to generate post-closure negative social impacts – real or perceived. These impacts can result from a decline in the local housing market, and changes to population demographics, infrastructure, employment, and community support historically contributed by the mine. While long-term, post-closure impacts are not direct responsibility of the Company, Perseus will work with the authorities and the communities to ensure that these impacts are minimized to the possible highest extent. However, factors like impacts magnitude and community vulnerability cannot be fully assessed at such an early stage of the project for the following reasons:

- The long-term time perspective of the occurrence of such impacts;
- The socio-economic transformations of the communities during the construction and operation phases.

For the closure phase that is planned after the 6 year lifetime of the mine, this ESIA anticipates a tentative assessment of impact significance ratings and identifies high-level mitigation and enhancement measures. These measures will need to be reviewed in a socio-economic section of the Closure and Rehabilitation Plan, after careful consideration of the new socio-economic conditions of the local communities. Mitigation/enhancement measures during the closure and rehabilitation phase can typically include the following:

- Plan closure and rehabilitation activities in cooperation with local authorities and communities (e.g. Community Consultation Committees);
- Keep into consideration the outcomes of socio-economic management plans (e.g. Vulnerability Assistance, Community Development Projects) in planning closure and rehabilitation activities; and
- Communicate clearly numbers and duration of the business and employment opportunities to manage expectations of the local communities.

Displacement Impacts include the following:

- Loss of agricultural land (cultivated, in preparation, young fallow);
- Loss of forest, bush and old fallow land.

Mitigation measures during the construction and operation phase include the following:

- Compensation for loss of productive land and standing crops and loss of access to economically-valuable assets that adhere to national standards and IFC Performance Standard (PS) 5. A separate Framework Livelihood Restoration Plan has been developed that includes the following:
    - Livelihood restoration programme;
    - Vulnerables People Management programme;
    - Grievance management;
    - Monitoring and evaluation;
- Support development of livelihood projects on agriculture intensification;
- Replacement (in cash or in-kind) of any built or planted assets lost due to land acquisition by the Project, including location and access advantages. Give preference, where possible, to in-kind compensation packages over cash-compensation entitlements;
- Livelihood restoration programmes to restore agricultural production and to support the development of alternative livelihood activities;
- Work with local authorities to improve local land use planning and support development initiatives (Land Use Plan and Community Development Plan);
- Re-vegetation programmes of rehabilitated areas and to restore/preserve habitats that can contribute to supporting ecosystem services;
- Defining an entitlement matrix to outline compensation rights for categories of impacted people;
- Providing support to government initiatives to encourage artisanal mining activities within the legal framework of the 2014 Mining Code; and
- Improving local land use planning and support development initiatives (see separate Community Development Plan).

All post-mitigation impacts have been rated moderate Negative to Major negative.

Population and Community Change Impacts include the following:

- Influx of people and increase in pressure on social facilities, infrastructure, and government;
- Influx-induced inflation;

- Social cohesion and increased community conflicts; and
- Increase in conflicts between locals and outsiders.

Mitigation measures during the construction and operation phase include the following:

- Procure goods and services locally whenever possible to increase local income levels as a countermeasure to expected inflation;
- Ensuring that per capita baseline water availability is maintained throughout the lifecycle of the Project;
- Supporting the development of community infrastructure and services;
- Recruit locally where possible to avoid competition for the limited residential structures in the study area if necessary, and where this is not entirely possible identify housing solutions (e.g. camps) for the highest number of workforce without competing with the community to have access to limited existing housing infrastructure;
- On-going in-migration monitoring along with regular feedback to local communities;
- On-going monitoring of local economy (livelihoods) and health with regular feedback to those affected;
- Development of a Local Economic Participation Plan to support the sustainable development of the local economy;
- Establishing monitoring and management plans to ensure that Project-led inflation does not reflect negatively on vulnerable households;
- Give preference, where possible, to in-kind compensation packages over cash-compensation entitlements to avoid circulation of excessive amount of liquidity;
- Where cash compensation is agreed, encourage households to accept cash compensation packages divided in installments over a number of years rather than opting for one-payment solution;
- Promote savings, safe investments and banking services as a form of sound management of financial entitlements;
- Creating credible governance structures - including influential members of the Community - to manage, monitor and supervise Project-related impacts;
- Supporting the extension of policing services at sub-prefectural level to prevent the intensification of violent conflicts;
- Conducting community health and security awareness campaigns in religious institutions, local governments, schools, and health posts;

- Cooperating with the UN bodies (i.e. ONUCI) for national reconciliation and appeasement of local communities;
- Work with local authorities and partners to ensure that local communities are aware of the inflation risks, receive training on financial management and can make informed choices about their earnings;
- Support the development of community infrastructure and services; and
- Monitoring in-migration trends, vulnerability indicators, restoration of livelihood projects and community development plans.

During closure, specific mitigation measures will need to be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operating phase.

Perseus will also implement a formal social mine closure process, whereby the community will be prepared for the impacts of closure, including the loss of jobs. During this process, a transition plan will be developed in a timely manner.

Note: The socio-economic and cultural heritage baseline studies have confirmed that there are no indigenous peoples present in the Project area, so that provisions of IFC PS 7 are not applicable to this Project.

0.2.10 Community Health, Safety and Security

Potential impacts on Community Health, Safety and Security that were identified in the ESIA process include the following:

- Community health impacts, increased likelihood of incidence of diseases including but not limited to sexually transmitted diseases (STDs), and social diseases associated with lifestyle changes;
- Community road safety impacts;
- Infrastructure and equipment design and safety, hazardous materials management and safety, and related impacts due to spills and equipment failure; and
- Community security.

Mitigation and enhancement measures in the area of Community Health, Safety and Security include the following:

- Health Services Program;
- Disease Prevention Programme for
    - Malaria;
    - Sanitation and water supply;
    - Sexually Transmitted Diseases (STDs);

- Community Health and Safety Awareness Programme for
  - Traffic Safety Awareness;
  - Hazardous Materials Management and Safety Awareness;
  - Emergency Response and Preparedness Awareness;
- Positive Lifestyles Program;
- Subcontractor Integrity Program; and
- Security with Integrity Program.

Overall, the Project will improve community health, safety and security, although some specific negative impacts may occur that can and will be mitigated. In general terms, communities will be most vulnerable and impact magnitude highest during the short-term construction phase when influx into the Project area is high and Project support programmes at the earliest stage. Stability during the long-term operations phase will provide opportunity for long-term and positive effects. Closure effects are often similar to construction effects, however, with the country progressing from the current post-conflict context, in-country stability will affect communities to a lesser magnitude than during the construction phase.

The following sub-sections describe the post-enhancement and post-mitigation impacts, respectively.

General health and wellbeing

The Project has the potential to contribute to the spread of communicable diseases through the influx of people into the region. Labour demands are highest during the construction phase and lowest during the closure phase.

The project site will feature facilities with stagnant water, including the tailings management facility and smaller water management ponds. If not treated these stagnant water bodies will introduce permanent potential mosquito breeding sites to the Project area.

If workers adopt lifestyle changes such as consumption of alcohol, tobacco use, drug use and change in diet these will negatively affect the health of these workers and their families can be impacted negatively.

Overall, general health and wellbeing will be improved in the project area due to the positive impacts of employment and income for project related households, including those households benefiting from non-project employment and income that has occurred as a result of the project.

Support for increased health services will reduce potential for morbidity and mortality and as well as contribute to worker health and availability for work. Support for improved sanitation and improved drinking water sources in the project area will reduce potential risks for transmissible diseases. Increased community awareness about disease transmission ways and lifestyle choices to avoid in mining communities will encourage workers and their families to choose behaviours that affect positive health impacts. Due to high influx and short-term duration of the construction phase, effects will be barely distinguishable during this time; however, long-term effects will become evident and clearly distinguishable as the operation phase progresses.

Community Road Safety

Although the Project will generate a negligible increase in traffic within the area of influence, general road safety culture is currently poor. As such, any Project related traffic incident would affect the safety performance of the Project negatively. Perseus will define clear expectations regarding road safety culture, road safety behavior and road safety training, for workers and contractors, and monitor traffic safety to minimise Project-related traffic injuries. Impacts would be indistinguishable in the areas of influence and of Low significance.

Infrastructure and Equipment Design and Safety

Perseus will meet international standards in construction design and methods by hiring companies experienced in large, international projects, with formal professional registration and certification to maximise adherence to international standard practices (IFC 2012). During project construction, operation and closure (rehabilitation), Perseus will be clear about its expectations with subcontractors and will continually monitor and evaluate companies' performance to ensure that the expected level of safety culture is achieved. Based on improved working conditions in the Direct Area of Influence, a positive impact would be clearly distinguishable in the areas of influence and of Moderate significance.

Hazardous Materials Management and Safety

Hazardous materials will be brought onto site by Perseus and subcontracted companies for construction and operations activities. These may include oils, diesel fuel, hydraulic fluid, process reagents (particularly cyanide). Perseus will endeavour to have Cyanide transported and managed under Cyanide Code criteria reducing spill potential.

The international standard, policies, self-enforcement, training and knowledge exchange residents occurs.

Violence and sexual violence may increase if ex-combatants migrate into the region. Perseus will need to monitor in-migration trends and vulnerability indicators, including incidence of sexual violence and perceived security. In addition, Perseus will support governance bodies and if necessary cooperate with UN bodies to prevent escalation of community violence.

Security services often attract ex-military personnel and ex-combatants. Legislation of Côte d'Ivoire deters their involvement, partially based on an association with sexual violence. As such, any negative effect of Project related security services on community violence, including sexual is expected to be barely recognizable and minor.

0.2.11 Cultural Heritage

An Archaeological and Cultural Heritage Study was undertaken by 2D Consulting (**Error! Reference source not found.**), and the available data and findings have been reviewed and summarised by Amec Foster Wheeler. The impacts on cultural heritage arise from the direct effects of construction on known and unknown archaeological remains at the proposed TSF site (pottery scatters and potential further buried remains) as well as direct effects on sacred sites (cemeteries and sacred forests). Mitigation measures include relocation of sacred sites in consultation with the relevant community and group leaders and the implementation of a Chance Finds Procedure during construction.

A specific Cultural Heritage Management Plan including a Chance Find Procedure has been prepared under this ESIA. A Relocation Plan to be developed by Perseus will address the relocation of the cemeteries and sacred forests.

The post-mitigation significance of cultural heritage impacts are rated Negligible.

From the data collected from existing reports, studies and during the field visit, Amec Foster Wheeler is not currently aware of any instances of intangible cultural heritage.

0.2.12 Landscape and Visual Impact

The primary purpose of the Landscape and Visual Impact Assessment (LVIA) is to determine the impact of the proposed project on the visual and aesthetic character of the study area. The rationale for this LVIA is that the proposed activity may fundamentally alter the landscape character and sense of place of the local environment.

Visual impacts result from the construction and operation phases of the Project. Specifically, the impacts would come from the waste rock storage area, the tailings storage area and the associated infrastructure areas, according to sensitive viewing angles, such as residents.

Negative effects are mainly related to visibility, visual field, landscape and landscape perception in the Project area.

Mitigation measures may not reduce these visual impacts significantly as the proposed activity cannot be screened sufficiently, mainly due to the scale and dimensions of the proposed infrastructure. The mitigation measures for the proposed activity will need to focus on effective rehabilitation of the disturbed areas.

It is important to note that should the area experience an influx of job seekers this will cause significant negative cumulative visual impacts that will be difficult to manage.

Mitigation measures include limited surface disturbance and prompt rehabilitation. These measures are prerequisite conditions if the severity of impact is to be reduced:

- In terms of artificial light it is important that security flood lighting and operational lighting should only be used where absolutely necessary and carefully directed, preferably away from sensitive viewing areas (e.g. nearby village of Allahou Bazi/Angovia and local roads). Wherever possible, lights should be directed downwards and shielded so as to avoid illuminating the sky and minimising light spills.

- Management measures required to mitigate the impacts associated with the TSF, WRD and other infrastructure include concurrent and end-of-life rehabilitation to ensure that the TSF and WRD blend in with the natural landscape. Sufficient screening the infrastructure in the forms of landscaped berms of vegetation screens will be installed and buildings and structures will be painted in colours that will blend in with the natural environment.
- Effective dust suppression will be implemented for air quality and visual reasons.
- It is important that potential cumulative impacts by influx of job-seekers are addressed. This is difficult to manage by Perseus and requires collaboration by the competent authorities and communities.

The importance of the different visual impacts of the Project could be high mainly because of the extent of visibility, proximity of villages and local roads compared to Project infrastructure (in terms of distance) and absorptive capacity moderate visualization of the surrounding areas.

The fact that the visual receptors have been assessed at low sensitivity results from the overall landscape and visual impact that will be of minor significance to the Project, if the mitigation measures are successfully implemented.

0.2.13 Emergency Preparedness and Response

Perseus is committed to prevent emergencies that could impact on human health and life, the environment or property. Should an emergency happen, despite all reasonable precautions taken, Perseus has the necessary resources and procedures in place to mitigate the consequences.

Major elements of the mining and process infrastructure relevant in the context of emergency planning include explosives for blasting operations, the cyanide process circuit, hazardous reagents, geotechnical slope failures, rock/mud slides, and failure of the TSF.

The approach of Perseus to the prevention of, and response to, emergency situations is described in the Emergency Preparedness and Response Plan (internal plan).

0.2.14 Transboundary Impacts

No transboundary impacts have been identified in the ESIA process for the Yaoure Project.

It should be noted that funding for all of Perseus' commitments, described above, in relation to community development, will come from community development funds and will be allocated by them according to their priority. Perseus will need to work with specialized NGOs to support communities in this prioritization process.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADR	Adsoption/desporption/regeneration
AfDB	African Development Bank
AIM	Alternative Investment Market (London)
AL	Alternative Livelihood
ANDE	Agence Nationale De L'Environnement (National Environmental Agency)
AoI	Area of Influence
AOP	Air Blast Overpressure
AQg	Air Quality Guidance
AQS	Air Quality Standards
AQMP	Air Quality Management Plan
ARD	Acid Rock Drainage
ARV	Anti-retroviral (drugs)
ASM	Artisanal and Small Scale Mining
BAT	Best Available Technology
BEIE	Environmental Impact Assessment Office
CDP	Community Development Plan
CDF	Community Development Fund
CIA	Central Intelligence Agency
CIAPOL	Centre Ivoirien Antipollution (Anti-Pollution Centre of Côte d'Ivoire)
CIE	Compagnie Ivorienne Electricité (Electric Power Company of Côte d'Ivoire)
CIL	Carbon-In-Leach
CIP	Carbon-In-Pulp
CIPOMAR	Compagnie d'Intervention contre les Pollutions du Milieu marin et lagunaire (Response Company against the Pollution of the Marine and Lagoon Environment)
CMA	Compagnie Minière d'Afrique
DFS	Definitive Feasibility Study
DMU	Discrete Management Unit
DTM	Digital Terrain Model
EA	Environmental Assessment
ECOWAS	Economic Community of West African States
EIA	Environmental Impact Assessment
EMP	Environment Management Plan
EPFI	Equator Principles Financial Institutions
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EU	European Union
FCFA	Franc de la Communauté Financière d'Afrique (currency, Franc of the African Financial Union)
FGD	Focus Group Discussion
FS	Feasibility Study
GHG	Greenhouse gas emissions
GRI	Global Reporting Initiative
HDPE	High density polyethylene
H&S	Health and Safety
HIV/AIDS	Human immunodeficiency virus/acquired immunodeficiency syndrome
IA	Impact Assessment
I&APs	Interested and Affected Parties
ICMI	International Cyanide Management Institute
ICMM	International Council on Mining and Metals
IEL	Inner Exploration Licence

IFC	International Finance Corporation
IFC PS	International Finance Corporation Performance Standards
ILO	International Labour Organisation
IUCN	International Union for Conservation of Nature
LGO	Low Grade Ore
LoM	Life of Mine
LRP	Livelihood Restoration Plan
LVIA	Landscape and Visual Impact Assessment
masl	meters above sea level
mbgl	meters below ground level
MIC	Maximum Instantaneous Charge
Mtpa	Million tonnes per annum
NEP	National Environmental Policy
NGO	Non-Governmental Organisation
NNL	No Net Loss
NPI	Net Positive Impact
NTFP	Non-timber forest products
NTS	Non-Technical Summary
OECD	Organisation of Economic Cooperation and Development
PAP	Project Affected Person
PCDP	Public Consultation and Disclosure Process
PEA	Preliminary Economic Assessment
PFS	Prefeasibility Study
PID	Public Information Document
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 µm.
PPE	Personal Protective Equipment
PPV	Peak Particle Velocity
PS	Performance Standard (IFC)
RAP	Resettlement Action Plan
ROM	Run of Mine
ROPS	Roll-Over Protection System
RPF	Resettlement Policy Framework
TSF	Tailings Management Facility
SAG	Semi-autogenous mill
SAP	Social Action Plan
SEP	Stakeholder Engagement Plan
SIA	Social Impact Assessment
SMP	Social Management Plan
SR	Scoping Report
STD	Sexually Transmitted Disease
ToR	Terms of Reference
tph	Tonnes per hour
TSF	Tailings Storage Facility
UNDP	United Nations Development Programme
UNOCI	United Nations Operation in Côte d'Ivoire
VIA	Visual Impact Assessment
WAEMU	West African Economic and Monetary Union
WBG	World Bank Group
WHO	World Health Organisation
WRD	Waste Rock Dump
WSD	Water Storage Dam
VAC	Visual Absorption Capability
UNICEF	United Nations Children's Fund
ZVI	Zone of Visual Influence

GLOSSARY

TERM	DEFINITION
Community	A group of people linked together by common characteristics, aims, culture and environment, often with family ties.
Consultation	Defined as a tool for managing culturally-appropriate two-way communications between Project sponsors and the public. Its goal is to improve decision-making and build understanding by actively involving individuals, groups, and organisations with a stake in the Project. This involvement increases a Project's long-term viability and enhances its benefits to locally affected people and other stakeholders. See IFC's public consultation *Good Practice Manual* for more details.
Environmental and Social Impact Assessment (ESIA)	An instrument to identify and assess the potential environmental and social impacts of a proposed Project, evaluate alternatives, and design appropriate mitigation, management, and monitoring measures.
Natural Resource	The environment, plants and animals and the products derived from them that are a benefit to humans.
Project	Yaoure Gold Mining Project of Perseus Mining.
Public Disclosure	The process of making information available to affected people and other interested parties, particularly with regard to the environmental and social aspects of Projects. Disclosure of information should be done in a timely manner, in publicly accessible locations, and in languages and formats readily understood by affected groups.
Social Impact Assessment (SIA)	Includes the processes of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions and any social change processes invoked by those interventions, so as to bring about a more sustainable and equitable biophysical and human environment.
Stakeholder Consultation	The process of engaging affected people and other interested parties in open dialogue through which a range of views and concerns can be expressed in order to inform decision-making and help build consensus. To be meaningful, consultation should be carried out in a culturally appropriate manner, with information in local languages distributed in advance.
Stakeholders	Stakeholders are persons or groups who are affected by or can affect the outcome of a Project. These can include affected communities, local organisations, NGOs and government authorities. Stakeholders can also include politicians, commercial and industrial enterprises, labour unions, academics, religious groups, national social and environmental public-sector agencies and the media.

1 INTRODUCTION

1.1 Background

Perseus Yaoure SARL (Perseus) is seeking to develop its 100 percent owned brownfield Yaoure Project in the Department of Bouafle in Côte d'Ivoire. The Yaoure Project has recently had a Definitive Feasibility Study completed for it.

Perseus has carried out an Environmental and Social Impact Assessment (ESIA) process, in compliance with the Mining Code of Côte d'Ivoire, Environment Management and Protection Code and Application Decree, as well as the IFC Performance Standards on Environmental and Social Sustainability.

In December 2014, Perseus retained Amec Foster Wheeler Earth & Environmental UK Ltd. as lead consultants of the ESIA. The ESIA is based on the Scoping Report that was prepared by AMEC Earth & Environmental UK Ltd. (AMEC, now Amec Foster Wheeler) and submitted to the environmental regulatory authority (ANDE) in November 2014. Following completion of the DFS in late 2017, Perseus need to update the ESIA to ensure alignment with the infrastructure layouts contained in the DFS.

The ESIA process in Côte d'Ivoire is regulated by Code No 96-766 of 3 October 1996 and Decree No. 96-894 of November 1996. In terms of the Code the first step in the ESIA process is to submit a Technical Report to ANDE which contains a description of the project, upon which ANDE issue the Terms of Reference (ToR) for the ESIA. During a meeting held with the National Environmental Agency and the Ministry of Environment on 7 July 2014, it was agreed that AMEC would prepare the ToR for the ESIA. The reason for this was that the ESIA also has to comply with IFC Performance Standards and other international best practice guidance, to facilitate funding by an international financial institution (IFI) should that be required. ANDE reviewed the ToR proposed by AMEC and approved it on 26 December 2014. On the basis of the ToR developed at the scoping stage and approved by ANDE, the actual ESIA work has commenced in January 2015. The two processes (IFC and National Regulations) were aligned to ensure that the requirements of the both the processes were met (refer to Table 1-1). The dates on which the various activities were completed are also indicated.

Table 1-1 Alignment of the Republic of Cote d'Ivoire and the IFC PS, 2012 ESIA Processes

IFC and World Bank ESIA Process		Cote d'Ivoire ESIA Process	
Process Activity	**Date**	**Process Activity**	**Date**
Scoping and Terms of Reference (ToR) for ESIA Completion and Submission	14/11/2014	Technical Summary Report and request for ToR Submission of Application to the Director General of the National Environmental Agency	14/11/2014
		Approval of ToR for ESIA by the National Environmental Agency	26/12/2014

IFC and World Bank ESIA Process		Cote d'Ivoire ESIA Process	
Process Activity	**Date**	**Process Activity**	**Date**
Undertake and Complete Baseline Studies	21/04/2015	Undertake and Complete Baseline Studies	21/04/2015
Assessment of impacts, impacts of alternatives and cumulative impacts and ESIA Reporting	10/05/2015	Assessment of impacts, impacts of alternatives and cumulative impacts and ESIA Reporting	10/05/2015
Development of ESMPs: mitigating, management and monitoring programme	10/05/2015	Development of ESMPs: mitigating, management and monitoring programme	10/05/2015
		Submission of the ESIA and ESMP to the Director of the National Environmental Agency	15/10/2015
ESIA and ESMP Disclosure	6/10/2015 to 9/10/2015	Public Hearing	18/02/2016 to 04/03/2016
		Inter-ministerial ESIA Inquiry	14/04/2016
External Review (should financing be required)		The Inter-Ministerial Committee convened by the National Environmental Agency (ANDE) issued a decision within two months of receiving the ESIA	14/04/2016
Monitoring and auditing against local and international standards and guidelines		Monitoring and external audits/ inspections by CIAPOL and third party consulting groups	

Côte d'Ivoire's environmental legislation, Act No. 96-766 of 3 October 1996 requires that an ESIA process be undertaken by, or involves, an environmental consultant who is approved by ANDE responsible for the administrative approval process. For this purpose Amec Foster Wheeler works in association with 2D Consulting, a local environmental consultancy officially accredited in Côte d'Ivoire.

The Project is an expansion of an existing dormant gold mining operation that started operating commercially in the 1980's. Apart from the open pit and heap leach facilities of former operators CMA and Cluff Gold, there is a widespread legacy of artisanal mining in the area. It is therefore important to understand from the outset that the Yaoure Project will be built and operated in a significantly degraded brownfield environment and not in a pristine environment (Figure 1-2 shows the extension of the existing operations). This is therefore an impact assessment looking at the net effect between the new operations and the impacts already caused by the historic operations. This fact is also reflected in this Environmental and Social Impact Assessment (ESIA) including the pre-Project baseline studies.

It is also important to note that this ESIA is based on preliminary information received from Perseus in April 2015 and some additional information received as a result of the 2017 DFS..

The ESIA inquiry was held on 14 April 2016 attended by the Inter-Ministerial Committee convened by the National Environmental Agency (ANDE), consisting of representatives of the different Government stakeholders, the Applicant and the relevant ESIA Consultants. During this meeting, the ESIA was discussed and additional information and clarification was requested on certain aspects, baseline conditions and management measures. In a letter dated 14 April 2016 from the Ministry of Environment and Sustainable Development it was noted that ANDE had approved the environmental license conditional to the provision of the outstanding information requested by the above-mentioned Inter-Ministerial Committee meeting. This information requested have been provided through an Addendum as a separate document and incorporated in the main ESIA report for final version.

Mining at the Yaouré Project area has been ongoing for approximately 150 years, initially thorough small scale artisanal type mining and since 1991 in the form of more commercial mining. Commercial geochemical trenching and core drilling began in 1991 as part of the Angovia 1 Project, which subsequently became the CMA Project. The CMA operations led to the development of initial open pits from 1999 to 2003, a processing plant and gold extraction through cyanide heap leach, whilst exploration continued. During this period the CMA Central, North and South pits were developed. The CMA permits were relinquished in 2004 and transferred to Cluff Gold (West Africa) in October 2004 who continued exploration, later under the new name of Perseus Mining plc in 2012.

The history of the various permits applicable to Yaouré are included in Table 1-2.

Table 1-2 Yaouré Gold Project Permit History

Designation	Decrees	Number and Type of Permit	Owner
Attribution	Decret 2002-376 du 31 Juillet 2002	PR-168: Research Permit	CMA : Compagnie Miniere d'Afrique
Transfer	Arrête 048/MEMME/DM du 08 Octobre 2004	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Renewal	Arrête 045/MEMME/DM du 29 Aout 2005	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Renewal	Arrête 035/MME/DM du 12 Novembre 2007	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2008-258 du 18 Septembre 2008	PE-33: Mining License	Cluff Gold West Africa (WA) Cote d'Ivoire
Authorization to work on ML 33	Letter 045/MMPE/CAB/ du 13 Mai 2013	PE-33: Mining License	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2013-840 du 11 Decembre 2013	PR 397: Research Permit in replacement of ML 33	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2015-665 du 30 Septembre 2015	PR-615: Research Permit	Perseus Mining Cote d'Ivoire SARL

1.2 Project Location

The Yaoure Gold Project is located in the Bouaflé Prefecture of the Marahoué Region in Côte d'Ivoire. The Project is approximately 40 km northwest of the political capital Yamoussoukro, 260 km northwest of the commercial capital Abidjan and 25 km from the regional capital Bouaflé.

The mine is located approximately 6 km west from Lake Kossou and the associated hydro-power station operated by the Compagnie Ivorienne d' Electricité (CIE). The Project location is indicated in Figure 1-1 and Figure 1-2.

Figure 1-1 Location of the Yaoure Project in Côte d'Ivoire

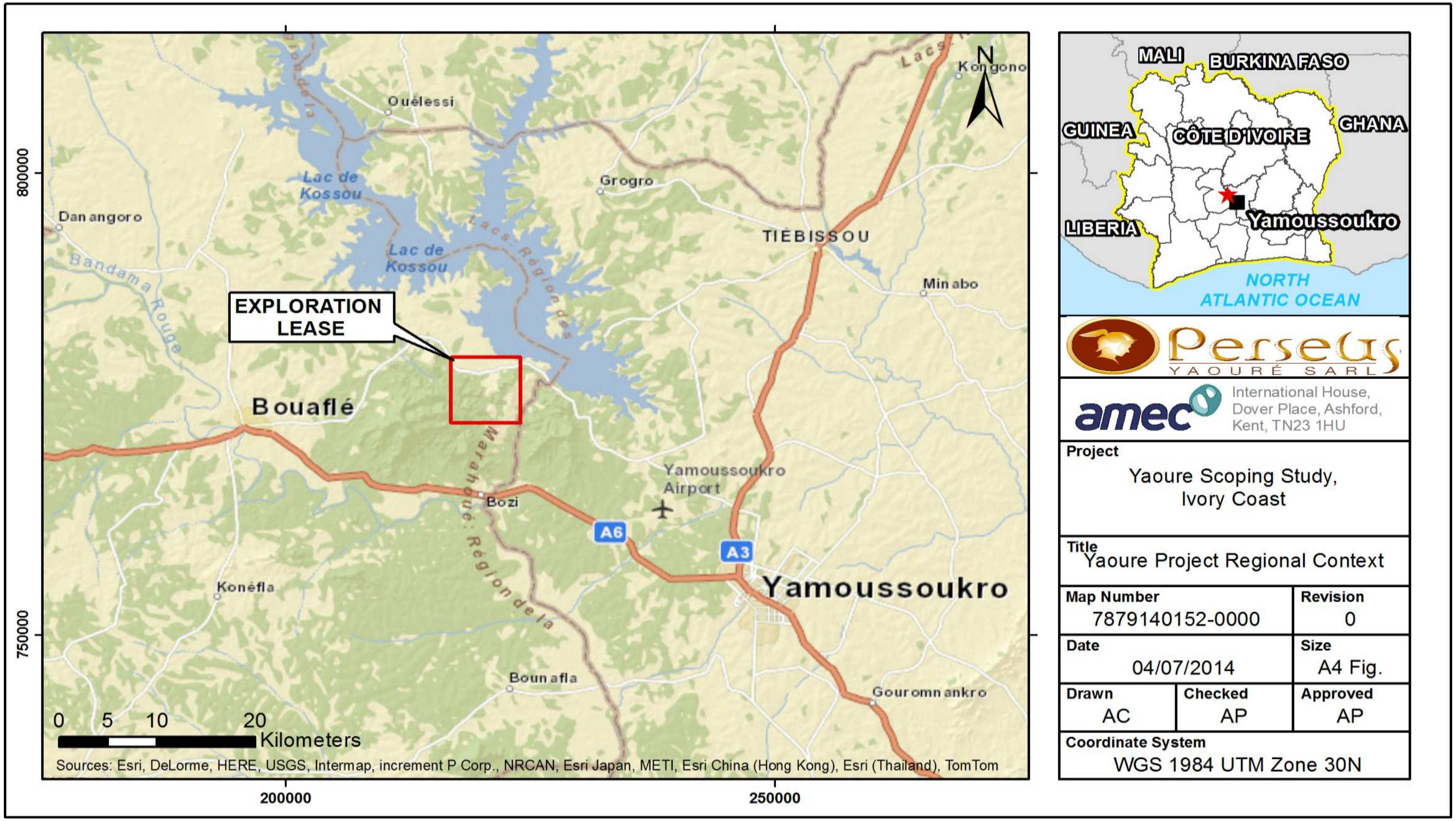
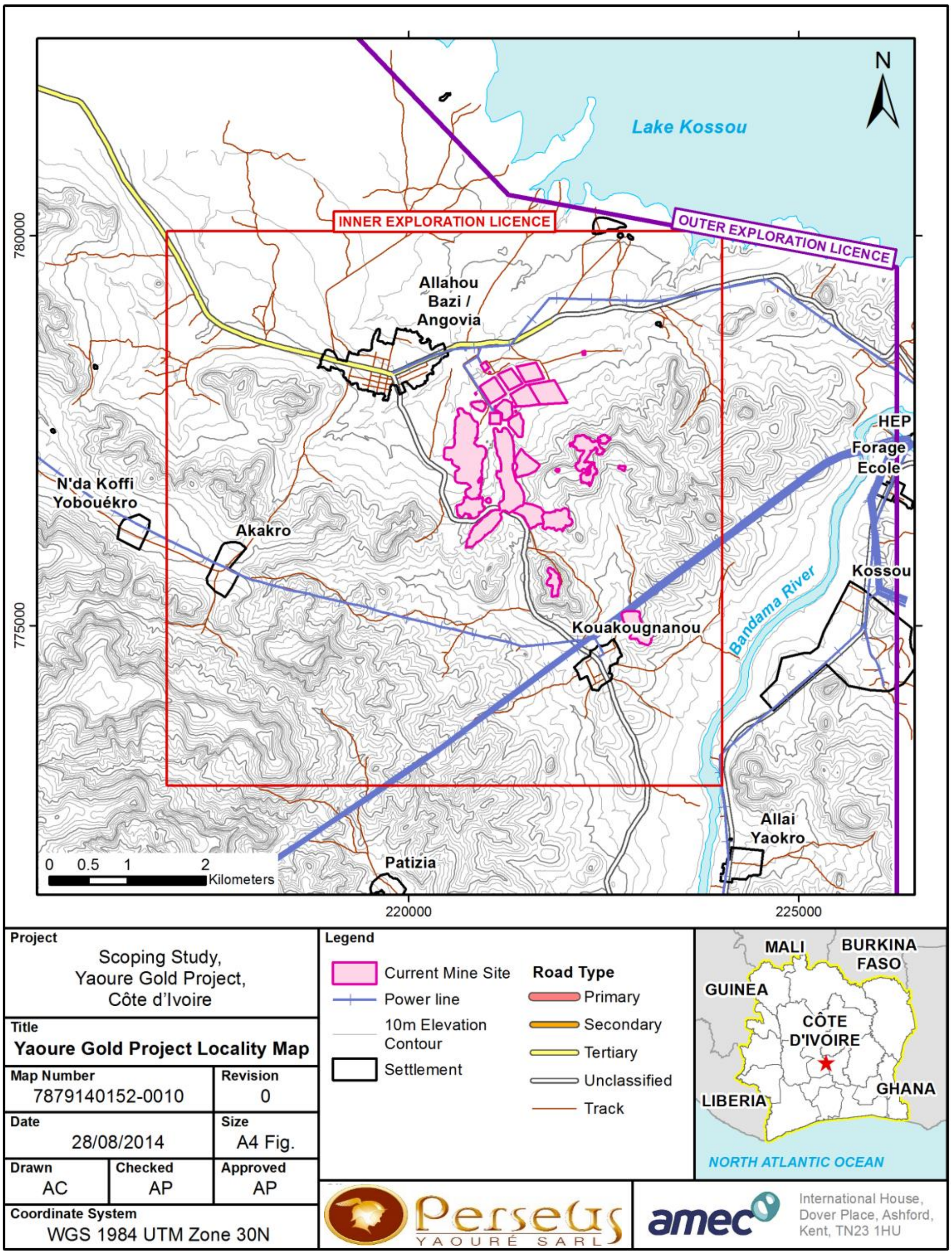


Figure 1-2 Yaoure Project Location (close-up)



1.3 Impact Assessment Objectives

This Environmental Social Impact Assessment (ESIA) presents an assessment of the potential environmental and social impacts associated with the proposed development of the Yaoure Gold Project in Côte d'Ivoire.

The ESIA process serves two functions:

- To provide the basis for decision-making, by the authorities and Project stakeholders on the environmental acceptability of the project; and
- To provide input to the project design as it evolves, on an iterative basis, to minimise negative impacts and maximise benefits of the Project.

Following from these functions, the objectives of the ESIA are to:

- Thoroughly document biophysical baseline conditions (pre-project conditions) of the study area and the socio-economic conditions of the affected communities, taking into account the brownfield nature of the Project;
- Inform, obtain and address contributions from stakeholders including relevant authorities and the public;
- Assess, in detail, the environmental and social impact that would result from the project, and compare the impacts with national and/or international environmental and social standards;
- Carry out the assessment for all life cycle phases of the project from construction to operation through to closure;
- Identify mitigation measures that would reduce the significance of predicted negative impacts or enhanced predicted benefits of the proposed mining projects, through a suite of Environmental/Social Management Plans (ESMP) that are part of the Project's Environmental and Social Management System (ESMS);
- Develop appropriate environmental and social monitoring plans for the Project (usually integrated into the ESMPs);
- Assess the impacts on health and safety of the workers, and on public health of the affected communities, and assess measures to mitigate these impacts;
- Meet the requirements of the environmental regulatory agency (ANDE) in Côte d'Ivoire as well as international best practice for projects of this nature; and

- Inform all stakeholders, through a Non-Technical Summary (see Section 0), about the main features of the proposed project, the expected impacts and the mitigation measures.

This ESIA is based on project information at the Feasibility Study (FS) development stage (most of the information was provided in March 2015). However, the information basis used in the ESIA process is sufficiently robust to draw conclusions on the environmental and social impact and to develop appropriate mitigation measures.

The ESIA Report describes and summarises the ESIA process carried out by Amec Foster Wheeler in collaboration with 2D Consulting (Côte d'Ivoire) and rePlan (Canada). The Baseline Studies and Management/Monitoring Plans are attached as Appendices (see Section 0 for a complete list of Studies and Plans).

1.4 Impact Assessment Scope

1.4.1 Summary of Findings of the Scoping Phase

The main issues that were identified during the Scoping Phase, and particularly as part of the scoping phase consultation are set out in Table 1-3, while the main concerns raised by stakeholders during consultation meetings are summarised in Table 1-44.

Table 1-3 Potential biophysical impacts identified during the scoping phase

Aspect	Identified Impacts, Risks and Opportunities
Surface Water	• Reduced water resources due to mine consumption via river abstraction • Flooding resulting from inappropriate hydraulic structure and drainage design • Contamination of watercourses, e.g., suspended solids, acidity and metals (ARD), cyanide, other reagents, fuel/hydrocarbons
Groundwater	• Dewatering of open pit may lead to lowering of water table • Contamination of groundwater by fuel/hydrocarbons, cyanide (from tailings pond) and heavy metals
Land Use	• Changes to traditional land-use due to land-take for mining and waste infrastructure
Soil	• Damage to soil structure due to trafficking or stripping and storing soil under wet conditions; stockpiling soil into heaps that are too high; or stockpiling soil for too long without proper protection or remediation • Spills or leaks of fuel and lubricants, • Loss of soil resource, • Potential compaction and erosion of any unprotected soil materials Loss of nutrients and loss of soil microbial activity while soil is in storage.
Ambient Air Quality	• Emission of exhaust gases from electricity generators, machinery and vehicles • Dust emissions from blasting and haul truck/vehicle movements; dust from stored materials and materials handling and processing; dust blow from construction areas cleared of vegetation, waste rock dumps and tailings surface (where dry) • Cyanide emissions from process plant and tailings
Noise and Vibration	• Traffic (haul trucks) and plant operation may lead to increased noise level • Blasting in open pit and potentially during construction
Biodiversity	• Loss of habitat for flora and fauna leading to impacts on species. • Displacement of fauna populations moved from areas to be developed. • Impacts to existing populations, breeding seasons/reproductive cycles and habitats elsewhere • Impact from noises associated with mining (blasting, vehicle movements, industrial processes, power plant etc.) on important or sensitive areas • In-migration and associated human population pressures on natural resources • Silty run-off pollution in water courses killing aquatic life
Climate	• Substantial CO_2 emissions from diesel generators and haul truck fleet
Visual and Landscape	• Open pit will create another "hole" in the landscape • Mining infrastructure, stockpiling areas and waste management areas (waste rock dumps and tailings) will impact on landscape if man-made structures are higher than dense forest
Cultural Heritage	• Loss of cultural assets (sacred sites, sacred forests, graves) • Loss of cultural norms and values, increased by influx of foreign job seekers in search of employment opportunities

Table 1-4 Concerns raised by stakeholders during scoping phase consultations

Aspect	Identified Impacts, Risks and Opportunities
Population and Demography	• Influx of workers from "outside", as well as job-seekers, related to the Project • Increased visibility of the region as a gold mining centre, leading to further influx of artisanal miners • Population growth, particularly during construction, which in turn will impact existing infrastructure (e.g., water supply), facilities, land use / land tenure, and natural resources • Risk of out-migration following construction phase
Economy and Employment	• Payment of taxes and royalties to the Government of Côte d'Ivoire • Inflationary pressures on local prices due to increased local demand • Increase in employment opportunities, particularly during construction – followed by a rapid decline thereafter • Risks that Project related employment is insufficient to meet local demands and expectations, and/or that unequal access is provided, leading to social conflict • Risk of economic dependency on the Project in nearby communities, particularly during construction • Changes in the availability of labour for other activities (e.g., agriculture) • Risk of economic instability following construction phase, caused by loss of employment
Current Occupation and Use of Project Footprint	• Reduction in productive land base available to local communities through land acquisition and risk that these will not be replaced post-closure • Displacement of existing livelihoods, including artisanal mining, farming, herding and potentially fishing (economic displacement) • Displacement of existing residences and communities (physical displacement) • Risk of impoverishment due to poorly planned and executed resettlement and livelihood restoration programmes (e.g., low levels of compensation, reliance on cash-only compensation) • Increase in pressure on land resources in the area and related difficulties in securing replacement lands • Potential loss of sacred forests and cemeteries • Host community impacts related to any necessary resettlement programmes
Community Organisation and Local Institutions	• Lack of necessary skills and capacity in local government and organisations to manage complex change processes • Changes to existing power structures and stakeholder relationships in local communities and organisations
Housing, Social Services and Infrastructure	• Increased pressure on existing housing and accommodation • Increased pressure on government services (e.g., education and health, policing) and infrastructure (e.g., roads, water, electricity) • Potential for project to improve local infrastructure, such as access routes • Risks associated with worker accommodation, including a "closed camp" and "open camp"
Health and Safety	• Increased nuisances, such as increased traffic, noise, dust and vibration • Higher risk of HIV/AIDS and other communicable diseases (e.g., STDs, Ebola) • Increased pressure on water supply, sanitation and solid waste management services • Risk of increased social issues, such as substance abuse, unwanted pregnancies, and crime

Aspect	Identified Impacts, Risks and Opportunities
Vulnerable groups and potential conflict in social Vulnerable groups and potential conflict in social web	• Risk of uneven distribution of benefits and impacts for vulnerable groups in local communities • Changes to existing gender roles, responsibilities and relationships • Risk of increased social conflict (e.g., between newcomers and more established residents), particularly over access to employment, land and infrastructure • Potential for the violation of human rights of disenfranchised populations

1.4.2 Technical Scope

The technical scope of this ESIA Report comprises the following:

- Open pit mine including ore and waste rock haul roads;
- Waste rock dumps;
- ROM pad and LGO stockpile;
- Process plant and associated conveyor systems;
- TSF with tailings pipeline corridor and water/seepage management structures;
- Workshops, laydown areas, fuel farm, chemical storage areas and power generator units;
- Construction and permanent camps with associated infrastructure, e.g. offices, workshops, sewage treatment and disposal;
- Clean and process water ponds;
- Overhead power line servitudes (including partial relocation of pylons in the proposed TSF area);
- Soil stockpile areas;
- Public roads, partially re-aligned around new Project infrastructure; and
- Access roads.

1.4.3 Geographical Scope, Areas of Direct and Indirect Influence

In the Scoping Report (AMEC, 2014), the areas of direct and indirect impact were identified. These areas are the basis for the geographical scope of the ESIA, and in particular the specialist baseline studies and impact assessments.

The main infrastructure footprints of the Yaoure Project fall within an area of approximately 50 km² (Inner Exploration Licence area, see Figure 1-2). The area of influence will, however, vary depending on the type of aspect or activity and the type and vulnerability or sensitivity of the receptors.

It is anticipated that impacts will mainly be confined to the main 50 km² footprint envelope, although the potential extent of the area of influence of potential impacts on the following environmental and social environments may be wider.

1.4.3.1 Surface Water

The area of influence (AoI) is downstream from the planned mine infrastructure, especially tailings storage facilities, open pit development, waste rock dumps, roads etc., until sufficient dilution has taken place so that the Project-related impacts are not measurable, or of no concern. Abstraction of water may also influence water levels and associated aquatic conditions. The extent of impacts and the AoI downstream will be determined by models in the Impact Assessment section of the ESIA (Section 8.1).

1.4.3.2 Groundwater

Seepage from groundwater into the open pit may require dewatering, which leads to a locally confined depression cone. Seepage from WRD and TSF infrastructure has potential to give rise to the formation of pollution plumes. The area of influence of potential impacts associated with dewatering and pollution plumes are assessed using groundwater models in the Impact Assessment section of the ESIA (Section 8.2).

1.4.3.3 Air Quality

The AoI associated with particular matter (e.g., PM10) and gaseous pollutants is typically up to a few kilometers from the dust and exhaust gas emitting operations. The dust and exhaust gas dispersion in the environment is strongly dependent on meteorological conditions and the presence of forests, topographical elements (hills) or man-made barriers such as safety berms. The AoI was determined through an air dispersion model which has been developed as part of the ESIA (Section 8.7).

1.4.3.4 Noise and Vibration

Noise impacts associated with day to day mining and mineral processing operations usually have an AoI of up to 2 km depending on the weather and acoustic absorption factors. The AoI of blasting vibration and air overpressure may be more extensive in terms of perceived effects, but the AoI of both aspects are modelled in the Impact Assessment section of the ESIA (Section 8.8).

1.4.3.5 Visual and landscape

Mining operations are currently well shielded from the north, east and south by a combination of vegetation cover and the natural topography with certain vantage points to the west from which they will be clearly visible. The AoI associated with light and visual intrusion has been assessed during the visual impact assessment but is not expected to exceed a few kilometers (Section 8.6).

1.4.3.6 Terrestrial and aquatic fauna and flora

The impact on terrestrial fauna and flora will be mainly confined to the immediate operational footprint area of the Project and areas with measureable noise and air quality impacts. However if animal migration routes are influenced, the AoI of indirect impacts will be wider. Pressure on hunting related to in-migration can also significantly increase the area of influence.

The AoI of aquatic impacts will be dependent on the connectivity with larger water bodies for instance the Bandama River, as discussed in Section 1.4.3.1 above. The AoI for each study field are included in Section 8.4.

1.4.3.7 Soil

During the Scoping Phase it was not anticipated that soil and land use activities will significantly exceed the footprint of the Project's operational areas. This was confirmed during the ESIA Phase (see Section 8.3).

1.4.3.8 Socio-economic conditions

The **Error! Not a valid bookmark self-reference.**3 illustrates the three areas of influence that have been defined for the purposes of the social impact assessment:

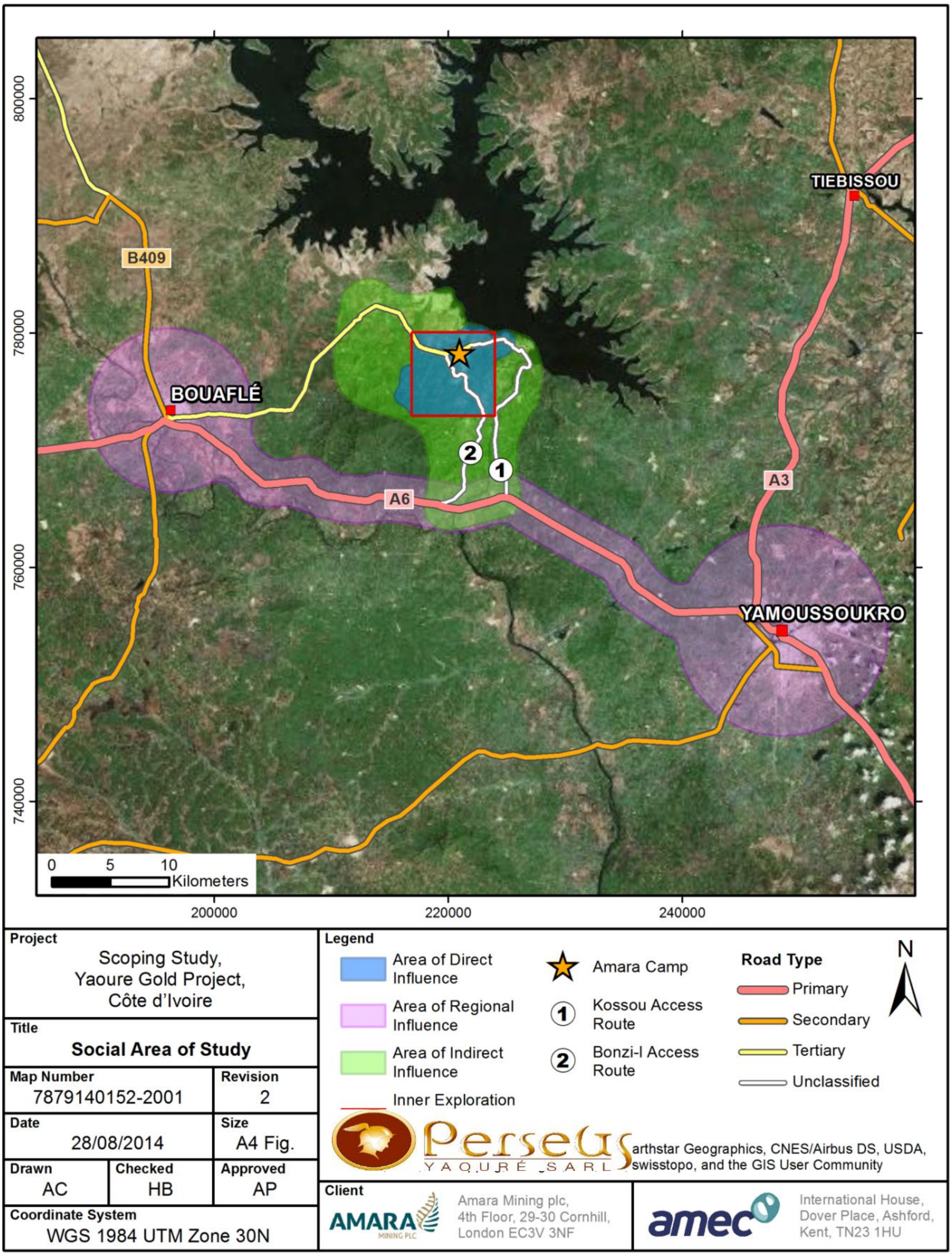
- Area of Direct Influence;
- Area of Indirect Influence; and
- Area of Regional Influence.

Each area corresponds to different types of social issues and requires specific types of baseline data to evaluate these issues and implement appropriate mitigation and benefit enhancement measures. Physical displacement impacts will be realised for any impacted land or property located within the Area of Direct Influence,

Importantly, these areas of influence straddle two different departments: Bouafle Department and Yamoussoukro Department. This must be taken into account in the stakeholder engagement activities.

Finally, the Project will have some national level significance, particularly in terms of government revenues.

Figure 1-3 Social Impact Areas of Influence



1.4.3.9 Cultural heritage areas of influence

The AoI on cultural heritage will be confined to the operational footprint of the Project, where cultural/archaeological remains and religious sites will be affected by project development activities.

From the data collected from existing reports, studies and during the field visit, Amec Foster Wheeler is not currently aware of any instances of intangible cultural heritage.

1.5 Structure of this Report

This ESIA Report has been prepared following international best practice (mainly the IFC Performance Standards, 2012 and UNEP, 2008), and in accordance with Article 40 of the Law n° 96-766 (3 October 1996) on the Environment Code of Côte d'Ivoire. Law 96-766 provides the following requirements with respect to the content of the ESIA:

- A description of the activity proposed, including infrastructure, reagents, energy sources etc.;
- A description of the environment likely to be affected including specific information necessary to identify or evaluate the impacts of the proposed activity on the environment;
- A list of the materials used;
- A description of Project alternatives;
- An assessment of the likely or potential impacts of the proposed activity on the environment, including direct, indirect, cumulative effects in the short, medium and long term;
- Identification and description of the measures to mitigate the impacts of the proposed activity, and an evaluation of these measures;
- An indication of knowledge gaps and uncertainties encountered in the development of the ESIA;
- An indication of potential transboundary impacts (if applicable);
- A brief summary of the information provided under the previous items.
- A description of environmental monitoring before project commencement (baseline), during construction, operation and after the end of the operation (closure, environmental rehabilitation);
- A financial estimate of proposed mitigation and offsetting measures and monitoring programmes.

The remainder of this ESIA Report is structured as follows:

- Section 0 describes the regulatory and institutional framework in Côte d'Ivoire in the context of this ESIA;
- Section 3 contains a description of the proposed gold mining Project;
- Section 0 describes the alternatives that were analysed in the process of this ESIA;
- Section 5 summarises the stakeholder engagement activities implemented as part of the ESIA process;
- Section 0 summarises the most relevant results of the environmental and social baseline studies that were carried out as part of the ESIA;
- Section **Error! Reference source not found.** briefly outlines the methodological approach to the assessment of environmental impacts pre and post mitigation;
- Section 8 analyses the impacts on the biophysical and social environment and assesses the effectiveness of mitigation measures;
- Section 8.11.4 looks at provisions for emergency preparedness and response;
- Section 0 considers cumulative impacts of the proposed Project;
- Section 0 describes the management system that Perseus will have in place to implement the mitigation measures described in this ESIA Report and associated Management Plans;
- Section 13 analyses gaps and uncertainties encountered in this ESIA, and how they were dealt with; and
- Section 0 contains the references used in the ESIA.

A list of all Appendices that are part of the ESIA documentation can be found in Section 0.

2 POLICY, LEGAL AND REGULATORY FRAMEWORK

A detailed review of the administrative, legal and regulatory framework has been prepared by 2D Consulting Afrique and is provided in **Error! Reference source not found.**. This section is an excerpt of the study in **Error! Reference source not found.**.

2.1 Policy Level

2.1.1 West African Economic and Monetary (WAEMU) level

Côte d'Ivoire has adopted the Common Policy within the WAEMU. The Member States have defined a policy framework which foundations are established by several acts. Chapter IV of the Additional Protocol No. 2 on sectoral policies of WAEMU, signed on 29 January 2003 in Dakar (Senegal), refers to the objectives and guiding principles of the Policy of Improvement of the Environment. The WAEMU Council of Ministers adopted a recommendation on the implementation of an environmental management programme with the following objectives:

- Fight against desertification;
- Preservation of biodiversity;
- Pollution management;
- The management of trans-boundary ecosystems;
- The fight against coastal erosion;
- The management of water resources;
- The promotion of alternative energy sources; and
- Capacity building.

2.1.2 Côte d'Ivoire

The National Environmental Policy (NEP), adopted by the Government of Côte d'Ivoire in 2011, aims at creating a framework for taking into account the environmental issues in development strategies and policies. The objective of the NEP is to ensure a healthy and sustainable environment and to preserve natural resources. Specifically, it addresses the following:

- Finding ways to address simultaneously the problems of economic development and poverty alleviation without further depletion or degradation of natural resources;

- Preserving or restoring the ability of ecosystems to provide goods and services essential to the maintenance of economic activities; and
- Improving the quality of receiving environments and the living environment.

In this context, the environmental policy specifies the main directions and following intervention dimensions:

<u>The horizontal strategic dimension</u> including the following:

- The promotion of a sustainable development strategy and the rational management of the natural resources;
- The strengthening of the institutional and legislative framework;
- The development of human resources;
- The implementation of a national system of information, education, and communication in environmental matters;
- The effective involvement of civil society;
- The prevention and fight against pollution and nuisances;
- The management of biotechnology and biosafety;
- The advancement of the sound management of hazardous chemicals; and
- Climate change.

<u>The vertical strategic dimension</u> including the following:

- Agriculture, breeding and fisheries;
- Improvement of land policy;
- Forest, wildlife, terrestrial, aquatic, and pastoral resources, desertification and biodiversity;
- Water resources;
- Transport and infrastructure;
- Energy;
- Industry, mining and petroleum operations;

- Human and environmental health;
- Human settlements;
- Tourism and culture;
- National education and scientific research
- Mitigation of poverty and population growth control.

In the area of social and economic development, Côte d'Ivoire has developed the National Development Plan (NDP) to address the long-term development vision for the country based on the cross-sectional and vertical growth sources for the period 2012-2015. This plan has replaced the Poverty Reduction Strategy Plan (PRSP) of 2000.

The new strategy builds on a recovery programme for ambitious but realistic development targets based on private and public investment. It also aims at bringing the country on a path to vigorous, sustained, and inclusive growth showing national solidarity, to enable Côte d'Ivoire to be emerging strengthened by 2020.

The implementation of this new strategy involves the creation of conditions that could transform the country into the following:

- A haven of peace, security, social cohesion and well-being;
- An economic power of the sub-region;
- A country of workers with discipline and respect for moral values;
- A country cultivating the excellence and the promotion of merit in equity;
- A friendly touristic country respectful of environmental values; and
- A financial centre of international class.

The NDP places strategic planning at the heart of public action and capitalises on the achievements of the process of the Poverty Reduction Strategy Document (PRSP) taking into account new challenges resulting from various crises experienced by the country over three decades, bottlenecks for the achievement of the Millennium Development Goals (MDGs) of the Economic and Financial Programme, the Presidential Programme and the country's potential sources of growth.

The NDP is the new reference framework for public interventions and political dialogue:

- To consolidate efforts towards the attainment of the completion point of the HIPC initiative;
- To promote the alignment of the budget of the State on the strategic priorities;
- To provide a basis for credible development actions programming;
- To professionally outline the operational outcomes of development actions;
- To obtain greater coherence in the actions of the various ministerial departments;
- To improve the effectiveness and efficiency of public expenditure;
- To serve as an advocacy tool for the mobilisation of external resources including private investment; and
- To provide a tool for monitoring and assessing development actions.

2.2 Constitutional Level

The legal framework and political/administrative system of Côte d'Ivoire is based on the Constitution of Côte d'Ivoire of August 2000, which has made the environment a priority.

Articles 19 and 28 stipulate the right of a healthy environment for all and explicitly state that "the protection of the environment and the promotion of the quality of life are a duty for the community and for every natural or legal person".

In terms of land access and resettlement, the Constitution states in Article 15 that the right to property is guaranteed to all and that "no person shall be deprived of their property if for cause of public utility and subject to the condition of a just and prior compensation".

2.3 Legal and Regulatory Level

2.3.1 Mining legislation

Law No. 2014-138 of 24 March 2014 on the Mining Code is the relevant legislative document for all mining activities. Article 5 requires a mining title and operating licence issued by the Ministry of Mines and Industry before any mining activity can commence.

The operating licence shall be granted by a Decree of the Council of Ministers, based on the information provided in a Feasibility Study, the content of which is defined in Article 28 as follows:

- An assessment of the reserves;
- An assessment of metallurgical treatment of the ore;
- A mine plan;
- A presentation of a programme of construction of the mine detailing the work equipment, facilities and supplies required for commercial production, as well as a cost estimate (CAPEX and annual OPEX);
- A study of the socio-economic impact of the project;
- A study of the environment impact (land, water, air, fauna, flora and human settlements) impact of the project with appropriate recommendations in accordance with the code of the environment and its subordinated documents;
- A complete financial forecasts for the period of operation;
- A Community Development Plan (CDP);
- Any other information that the party establishing the feasibility study considers useful, especially related to project funding by financial institutions; and
- Conclusions and recommendations on the economic feasibility and the timetable for the start-up of the commercial production, taking into account the above listed items.

It is specifically noted from the above list that an Environmental and Social Impact Assessment is required as a precondition of the mining licence. This is specified further in Art. 141.

Article 113 acknowledges restricted areas from which a 100 m wide buffer has to be maintained. These include: closed properties, protected areas, wells, religious buildings, cemeteries or places considered as sacred, main roads, water pipelines and water bodies, public utility works, art work and any public domain. Article 114 furthermore indicates that exploitation within the restricted areas is subject to prior consent from the owners, occupants, communities or relevant Minister.

Article 124 requires holders of a mining permit to prepare a Community Development Plan (CDP) in collaboration with neighbouring communities and territorial and local administrative authorities, with a specific set of objectives and an investment plan. Article 128 stipulates that the CDP referred to in Article 124 shall cover the following areas:

- Development of infrastructure and basic facilities:
- Development of basic social services and the environment;

- Employment;
- Development of the local economy; and
- Development of human capital.

Relations between the licence holder and the occupants of the land are defined in Art. 127. The occupation of lands that are required by the mining operations gives right to fair compensation of the legitimate occupant of the land. The terms of this compensation are defined by Decree[1]. This compensation is governed by a Memorandum of Understanding between the operator, the legitimate occupant of the land, under the supervision of the Administration of Mines and the Ministry of Agriculture.

Disputes regarding the amount of compensation payable or any other related materials are submitted for arbitration to the competent administrative structures under the conditions laid down by Decree (see Art. 135 of the Decree No. 2014-397 of 25 June 2014 laying down the procedure for the application of the law No. 2014-138 of 24 March 2014 on Mining Code).

Article 131 requires that for each operation, a Local Mining Development Committee is set up by joint order of the Minister of Mines and the Minister of Local Administration, in accordance with Article 125 of the Mining Code. This Committee consists of:

- The Prefect of the District;
- The Chairman of the Regional Council;
- Sub-prefects, MPs and mayors of affected communities;
- Representatives of affected communities;
- Representatives of the Administration of Mines; and
- Representatives of the operating company.

The Prefect of the District shall preside over the Committee. The Vice-Chairman shall be the Chairman of the Regional Council. The Mining Administration shall provide the Secretariat of the Committee.

Article 140 requires that mining activities shall be carried out so as to ensure the protection of the environment, the rehabilitation of the sites and the conservation of the forest heritage in line with the conditions and modalities established by the regulations in force. Article 141 requires that an applicant of an operating permit, before undertaking

[1] Loi n°98-750 du 23 Novembre 1998 relative au domaine foncier rural modifiée par la loi 2004-412, du 14 Août 2004 ; decret 2014-25 du 22 Janvier 2014, modificant le decret 2013-224 du 23 Mars 2013, portant reglementation de la purge des droits coutumiers sur le sol pour intérêt général; Arrêté Ministériel n°247 MINAGRI/MPMEF/MPMB du 17 Juin 2014, portant fixation du barême d'indemnisation des cultures détruites

any operations shall carry out and submit an ESIA for approval by the Mining Administration, Environment Administration (ANDE) and any other competent authorities provided for by the mining legislation.

The ESIA shall contain an Environmental and Social Management Plan (ESMP, typically consisting of a suite of Management and Monitoring Plans in all affected specialist areas, forming an Environmental and Social Management System, or ESMS), including a Rehabilitation Plan of the sites and an estimation of closure and rehabilitation costs. Any substantial amendment to the ESMP shall be subject to a prior authorisation of the competent authorities for mining and environment.

With a view to preserving the health and welfare of the neighbouring communities of mine sites, the licence holder shall carry out periodic reviews of the effectiveness of the ESMP as approved by relevant regulatory authorities, and, where appropriate, by a suitably qualified expert/organisation, appointed by the competent regulatory body.

In the event of a pollution spill, the cost of monitoring, verification and subsequent fines incurred shall be charged to the licence holder.

Article 142 requires the holder of an operating permit to implement the ESMP as approved by the mining authority and environment authority.

Article 144 stipulates that an escrow account shall be established for environmental rehabilitation at the start of the mining operation. It shall be set up in a leading financial institution in Côte d'Ivoire. This account shall cover costs related to environmental rehabilitation at the end of mine life. Payments into the account are made by the licence holder according to a schedule established by the competent authority.

Article 145 requires the applicant for an operating permit to provide, along with the ESIA, a Mine Closure and Rehabilitation Plan. The Plan shall be submitted for approval by competent authorities for mining and the environment. If/when changes in the mining operations require a change in the Closure Plan, the permit holder shall submit a revised Plan for review.

The Closure Plan shall take into account the following aspects:

- Clean-up of the mine site;
- Dismantling and removal of mining facilities;
- Rehabilitation of the site;
- Post-rehabilitation monitoring of the site;
- Possible conversion of the site for other purposes; and
- Transfer (return) of the rehabilitated site to the competent authorities.

Article 147 requires that the Closure Plan shall describe the procedures, equipment and techniques foreseen for dismantling and rehabilitation. The Plan shall also provide for concurrent (or progressive) rehabilitation works during the operation phase of the mine.

Article 148 defines civil liability of a licence holder for damages and accidents which might be caused by the facilities over a period of five years after closure.

Title XI (Article 151-154) of Decree No. 2014-397 of 25 June 2014 laying down the procedure for the application of the law No. 2014-138 of 24 March 2014 on the Mining Code specifies the requirements to the financial guarantee for closure and rehabilitation ("Closure Fund"):

Article 151 stipulates that the trust fund shall be readily available at request; its size shall be determined based on the ESIA that takes into account the environmental risks at closure and during post-closure.

Article 154 requires that in case the operator fails to comply with his obligations to rehabilitate the mine, the State has full access to the guarantee and may at its own discretion use the funds for environmental rehabilitation of the mine.

2.3.2 Environmental Protection

Environmental protection is regulated by Law No. 96-766 of 3 October 1996 on the Environment Code.

Under Article 22**,** the competent authority for environmental protection (ANDE) may refuse to issue an environmental permit if the proposed project negatively affects the surrounding environment.

Article 35 introduces a series of fundamental principles of environmental protection in Côte d'Ivoire:

- Article 35.1 refers to the precautionary principle and requires that during the planning or execution of any activity, precautionary measures must be taken to avoid or reduce any risk or danger to the environment. Prior to project implementation, any person whose activities are likely to have an impact on the environment must take into account the interests of third parties and the need to protect the environment. If, in the light of scientific evidence or experience, an activity is deemed to likely cause a risk to the environment, this activity can only be implemented after a prior assessment indicating that it will have no unacceptably adverse environmental impact;

- Article 35.2 specifies that if a proposed activity could have an adverse environmental impact, it should be substituted by an alternative with lower risks even if this entails higher costs;

- Article 35.3 requires the preservation of biological diversity (see also Sub-Section 2.3.6 of this Report);
- Article 35.4 requires the licensee to prevent degradation of natural resources and to strive for sustainable development. Irreversible effects on land should be avoided as far as possible;
- Article-35.5 introduces the "polluter pays" principle: any natural or legal person whose actions and/or activities are causing or are likely to cause damage to the environment is liable to financial compensation; and
- Article 35.6 provides for the right of the public to participate in all procedures and decisions that could have a negative effect on the environment.

Article 39 requires an Environmental Impact Study for all development projects likely to have impacts on the environment.

Articles 50, 57 and 75 make provision for the protection of thresholds and limits associated with pollutants to air and water.

Other provisions of Law No. 96-766 are considered in more detail in **Error! Reference source not found.**.

Decree No. 98-43 of 28 January 1998 on Classified Installations for Environment Protection requires that certain industrial installations (including mines, quaries, workshops and plants) require prior authorisation regarding environmental compliance by the Minister of the Environment. The Yaoure Project would be subject to this Decree.

Other regulations that are analysed in detail in **Error! Reference source not found.**, as they may be relevant to the Project include the following:

- Decree No. 2005-03 of 6 January 2005 on Environmental Audit;
- Decree No. 2012-1047 of 24 October 2012 Laying Down the Procedures for the Application of the Polluter-Pays Principle as defined by the Law No. 96-766 of 3 October 1996 on the Environment Code; and
- Decree No. 2013-440 of 13 June 2013 Determining the Legal Regime of Protection Zones of Water Resources.

2.3.3 ESIA related regulations

Decree No. 96-894 of 8 November 1996 Determining the Rules and Procedures Applicable related to Environmental Impact Studies of Development Projects determines the rules and procedures applicable to the ESIA process and specifies rules for the application of Article 39 of the Act establishing the Code of the Environment (see Section 2.3.2 above).

Art. 12 describes the content of an ESIA, with an outline of the ESIA in Annex IV of the Decree.

Art. 16 stipulates that a project under consideration in the ESIA is subject to public consultation. The ESIA documentation is made public as part of this process.

Art. 40 of the Act No. 96-766 defines the content of an ESIA (see Section 1.5 above).

2.3.4 Water

Law No. 98-755 of 23 December 1998 on the Water Code defines mechanisms for sustainable management of water resources. It introduces the concept of river basin and watershed management, strengthens the institutional framework in the water sector and puts particular emphasis on planning and cooperation in the management of water resource.

Water management shall aim at ensuring the following key objectives:

- The preservation of aquatic ecosystems and wetlands;
- The protection against any form of pollution, the restoration of surface water, groundwater and sea water within the limits of water territories;
- The protection, mobilization and management of water resources;
- The development and the resilience of hydraulic facilities and structures;
- The recognition of water as economic resource, to enable its distribution to meet or reconcile the requirements of different water users, such as:
    - The supply of drinking water to the population;
    - The health, public safety, and civil protection;
    - The conservation and the free flow of water and flood protection;
    - Supply of water to agriculture, fisheries and marine cultivation, fishing in freshwater, industry, energy production, transport, tourism, recreation and water sports as well as all other human activities legally pursued;
- The consistent planning of the use of water resources both at the level of the hydrological basin watershed and nationally;
- The improvement of the living conditions of the population, in equilibrium with environmental needs;

- The rational and sustainable use of the water resources for present and future generations; and

- The establishment of an institutional framework characterised by the redefinition of the role of stakeholders.

The Law makes provision for:

- Potential permitting or levies for water use through abstraction and the installation of water works (Article 12); and

- Approval of water use for industrial purposes (Article 89).

Water discharge limits are set in CIAPOL Decree No. 01164 of 4 November 2008, see

Table 2-1. For comparison, the guidance values of the IFC EHS Guidelines for the mining industry (2007) are also shown in

Table 2-1.

Table 2-1 Applicable water discharge standards

Parameters	Concentration limit as per CIAPOL (2008)	Concentration limit as per IFC EHS Mining (2007)
pH	5.5 - 8.5 (9.5 with chemical treatment)	6-9
Cadmium (Cd)	n.a.	0.05 mg/l
Lead (Pb)	0.5 mg/l if the discharge load exceeds 5 g/day	0.2 mg/l
Copper (Cu)	0.5 mg/l if the discharge load exceeds 5 g/day	0.3 mg/l
Chrome (Cr)	0.5 mg/l if the discharge load exceeds 5 g/day	n.a.
Hexavalent Chrome (Cr-VI)	0.1 mg/l if the discharge load exceeds 1 g/day	0.1 mg/l
Nickel (Ni)	0.5 mg/l if the discharge load exceeds 5 g/day	0.5 mg/l
Zinc (Zn)	2 mg/l if the discharge load exceeds 20 g/day	0.5 mg/l
Manganese (Mn)	1 mg/l if the discharge load exceeds 10 g/day	n.a.
Tin (Sn)	2 mg/l if the discharge load exceeds 20 g/day	n.a.
Iron, aluminium and compounds (Fe +Al)	5 mg/l if the discharge load exceeds 20 g/day	2 mg/l
Arsenic (As)	0.05 mg/l if the discharge load exceeds 0.5 g/day	0.1 mg/l
Zinc (Zn)	n.a.	0.5 mg/l
Mercury (Hg)	n.a.	0.002 mg/l
Fluorine compounds (F)	15 mg/l if the discharge load exceeds 150 g/d	n.a.
TSS	50 mg/l if the discharge load exceeds 15 kg/day, otherwise 150 mg/l	50
Cyanide (CN)	0.1 mg/l if the discharge load exceeds 1 g/day	0.1 mg/l CN_free 0.5 mg/l CN_WAD 1 mg/l CN_total
Total Hydrocarbons	10 mg/l if the discharge load exceeds 100 g/day	n.a.
Phenols	n.a.	0.5 mg/l
COD	300 mg/l if the discharge load exceeds 150 kg/d, otherwise 500 mg/l	150 mg/l
BOD_5	100 mg/l if the discharge load exceeds 50 kg/d, otherwise 150 mg/l	50 mg/l
Oil and Grease	30 mg/l if the discharge load exceeds 5 kg/d, otherwise 10 mg/l	10 mg/l
Nitrogen compounds	50 mg/l if the discharge load exceeds 100 kg/day	
Temperature	< 40 degrees C	< 3 degree C differential

The requirement of a sustainable usage of water is provided for in Decree No. 2013-441 dated June 2013.

2.3.5 Air quality and noise standards

Air emission rates and concentrations, as well as noise standards are set in CIAPOL Decree No. 01164 of 4 November 2008 and are summarised in Table 2-2 and Table 2-3. They are discussed in more detail in Sections 8.7 and 8.8 of this Report.

Table 2-2 Air quality standards

Substances	Applicable at hourly release rate of	Maximum allowable concentration (mg/m^3)
Total dust	< 1kg/h >1kg/h	100 50
Carbon monoxide	>1 kg/h	50
Sulphur oxide (expressed as sulphur dioxide)	>25 kg/h	500
Nitrogen oxide (expressed as nitrogen dioxide)	>1 kg/h	50
Discharges of various gaseous substances such as HCN	>50mg/h	5 mg/m^3

Table 2-3 Noise standards (all figures in dB)

Zones	Time		
	Day	Intermediate period	Night
Hospital areas, recreational areas, areas of natural protection	40	35	30
Residential or rural areas with low road traffic, traffic on waterways or air traffic	45	40	35
Urban residential areas	50	45	40
Urban residential areas, with some workshops or business use, or with certain degree of road/waterway/air traffic, and in the rural communities	60	55	45
Areas with predominantly of commercial/industrial activities	70	65	50
Area with predominantly industrial use	75	70	60

2.3.6 Biodiversity Protection

Act No. 65-255 of 4 August 1965 on Fauna Protection and Hunting contains provisions on the protection of wildlife and a number of Appendices with protected species.

Law No. 2014-427 of 14 July 2014 on the Forestry Code aims at preserving and promoting biodiversity and contributing to the balance of the forestry ecosystems and other ecosystems. It requires that the operator of a mine preserves and enhances biodiversity on the project site.

Decree No. 97-678 of 3 December 1997 on the Protection of the Marine and Lagoon Environment against Pollution prohibits the pollution of the sea and lagoons, in accordance with the provisions of Article 96 of the Environment Code. It may be relevant to the Yaoure Project because water pollution of the Bandama River may affect the sea at its estuary in the Gulf of Guinea, and the Tagba Lagoon.

2.3.7 Emergency Preparedness and Response

Decree No. 98-42 of 28 January 1998 on the Organisation of the Emergency Plan Against Accidental Pollution of the Sea, Lagoons and Coastal Areas sets out requirements to develop an emergency plan and to co-ordinate emergency planning and response activities with the Company of Intervention Against the Pollution of the Sea and Lagoon environment.

All authorities, State agencies, officers of public and private corporations and any person discovering a marine, coastal and lagoon pollution, must transmit this information immediately to CIPOMAR.

The Inter-Ministerial Instruction No. 070INTP.C. of 13 May 1994 on the Organisation of Technical Accident Relief (Plan ORSEC) requires that an Internal and an External Emergency Preparedness and Response Plan are developed, based on a study of potential hazards and accident scenarios.

2.3.8 Sustainable development and environmental information

Article 37 of the Act No. 2014-390 of 20 June 2014 on Sustainable Development requires that private sector companies adhere to the principles of sustainable development and adopt the following principles:

- Responsible procurement, operations, production and management methods to ensure sustainable development;
- Environmental and social assessment;
- The adoption of principles of sustainable development and environmental protection by their business partners, including suppliers;
- Transparent communication of environmental management; and
- Compliance with the requirements of corporate social responsibility.

2.3.9 Public health and safety

Law No. 88-651 of 7 July 1988 contains provisions on the protection of public health and environment against the effects of industrial toxic and nuclear waste and harmful substances.

2.3.10 Cultural Heritage

At present, policies relating to the protection and management of cultural heritage within the Côte D'Ivoire are not well defined. Act No. 87-806 (28 July 1987) on the Protection of Cultural Heritage indicates an obligation to inform the department of cultural affairs and mines in the event of archaeological discovery, and an additional act (Act No. 96-766 dated 3 October 1996), which relates to environmental protection, includes the need to protect landscapes and national monuments. However there is little applicable legislation beyond this.

As a result, the IFC Performance Standards, which are widely seen as a benchmark for best practice in the conduct of Environmental Assessment, will be used for this study in conjunction with the UNESCO (2003) *Convention for the Safeguarding of Intangible Cultural Heritage*.

2.3.11 Land Tenure and Use Rights

2.3.11.1 Land use, expropriation and resettlement

Expropriation for public purposes is governed in Côte d'Ivoire by the Decree of 25 November 1930. The expropriation procedure stipulates the following:

- Public utility must be legally established by a Declaration of Public Utility (DPU);
- Everything must be done to minimise the extent of expropriation;
- Compensation is a condition for the expropriation, and must take place prior to expropriation; and
- Compensation must be fair.

Customary land ownership and land use is acknowledged by Decree No. 71-74 of 16 February 1971. The Decree states that land and the right to use the land belong to the people. It further states that these rights cannot be transferred in any capacity whatsoever. No one can purchase these rights throughout the territory of Côte d'Ivoire.

Act No. 98-750 of 23 December 1998 on rural land as amended by law No. 2004-412 of 14 August 2004 contains provisions related to rural land use customary rights. It establishes the foundations of the land policy in rural areas, namely (i) the recognition of a customary rural estate and (ii) the role of village authorities and rural communities in the management of the rural area and in particular to the recognition of customary rights. The Yaoure gold project is subject to this Act, as it is carried out in an agricultural environment, in rural areas where populations have customary rights on land.

Decree No. 2014-25 of 22 January 2014 amending Decree No. 2013-224 of 22 March 2013 Regulating the Removal of Customary Rights of Land for the General Interest defines standards and procedures for the compensation for the loss of income of land owners. It allows the following ways of compensation:

- In-kind compensation;
- Land with and without equipment;

- Cash compensation; and
- A combination of in-kind and cash.

Decree No. 2014-397 of 25 June 2014 Laying Down the Procedure for the Application of the Law No. 2014-138 of 24 March 2014 on the Mining Code provides formulae with which to calculate the compensation for land used by mining activities. It is based on parameters such as annual income from a land plot and average price of land. The Ministry of Agriculture with the Directorate General of Rural Development will be involved in the determination of these calculation parameters.

2.3.11.2 Principles of Customary Rural Land Management

Beginning in 1971, and then more decisively in 1998 with Act No. 98-750, legislation of Côte d'Ivoire has come to acknowledge the existence of customary land rights and the jurisdiction of traditional village authorities and rural communities over land use. Since 1998 the government of Côte d'Ivoire has sought to formalise land rights with a view to registering ownership. However, this effort has been frustrated by an anaemic public response to government requests to register their customary ownership rights. Indeed, rural land management systems in Côte d'Ivoire continue to operate largely on the margins of national legislation. 98% of rural land management transactions are carried out according to custom. As a consequence, land disputes are frequent and administrative-legal institutions are hard pressed to bring them to resolution.

One of the basic foundations of customary land management in Côte d'Ivoire is the general acceptance of the principle that rural lands cannot be sold. Custom makes a clear distinction between ownership of land, which belongs to the community (family, lineage, village), or, depending on local circumstance, to a notable personage, land chief, lineage, or the founding families of the village, and the right of use, which may be transferred to members of the community or non-members alike. The beneficiary of a right of use bestowed by a customary landowner can establish plantations, grow crops, and reap all the rewards, but simple use or occupancy does not imply ownership. Adverse possession is not recognised in the legislation of Côte d'Ivoire or customary law.

Usage rights may be transferred for a fee, a share in harvests, or some other benefit. Despite the customary principle that land is inalienable, financial transactions, economic interests and political pressure have often fostered more or less voluntary misunderstandings about the nature (temporary or permanent) of land disposals. These misunderstandings have given rise to many land disputes, especially recently, when the economic crisis led many young people to return to their rural communities in search of employment and livelihood. Many of their family lands had been occupied or "sold" to migrants and/or other non-community members in their absence.

2.3.11.3 Ways to Obtain Rural Land Access

Sales

The only authorised type of sale under customary law is that of usage rights. An operator who has obtained the right to use a parcel of land and has established a plantation may sell his rights to a third party on the condition that the landowner agrees to the transfer. The issue of the transfer of ownership, per se, is more complicated as transactions of this sort are seldom recognised as legitimate, either from a legal or customary perspective.

To the extent that land sales do occur, terms of agreement tend to lack detail and often fail to specify the scope or the limits of commitments. Confusion often arises between a landowner, who believes they are selling usage or access and the purchaser, who believes they have acquired a permanent right. Interpretations differ as to whether these sales practices reflect a change in local customs or an outright contradiction with custom.

Sharing Agreement

Under customary law, a landowner and a farmer can share the benefits of an established plantation. In principle, sharing occurs when planting is about to enter the production phase. Revenues from the sales of produce are shared between the user, who is compensated for cultivating the land, and the owner, according to percentages established in the initial agreement.

Rental Agreement

Rental agreements are conventional contracts that determine a temporary use of rural lands. Normally these types of contracts allow users to choose which annual crops they can grow on an agricultural plot. Users pay a rental fee set out in the initial agreement to the landlord.

Allocating / Pledging of Plantations

The owner of a plantation can pledge it to a third person in exchange for money. The third person recovers the initial cash outlay from the harvest. Generally, the parties specify the duration of the exploitation, taking into account the amount of the loan and the value of the plantation. Disputes may arise in the case of long-term pledges made without a written agreement or on the basis of an imprecise agreement. A typical example of these conflicts results when one party maintains the transaction constitutes a pledge, while the other asserts it represents a sale of the plantation.

Expropriation

Rural/agricultural land may be expropriated for public purposes provided every possible effort is made to minimise the extent of the expropriation and that fair and prompt compensation in the form of in-kind compensation, land, both with and without equipment, cash, or a combination of cash and in-kind compensation is provided.

Land Rights of Women in Customary Laws

Most women in Côte d'Ivoire enjoy no specific control of rural lands. They are normally granted indirect access through their male family members: father, husband, brother, or uncle. Therefore, although women play a vital role in agricultural production (weeding, planting, maintenance and protection of crops, harvesting, and selling in markets), they cannot dispose of, sell, or inherit ownership rights. Custom dictates that land should remain in the original lineage to which it belongs.

Systems of succession of ownership rights can be matrilineal or patrilineal. In both cases, the attribution and inheritance of lands are determined by direct linkages within the lineage. In order to avoid dispersion of land assets within the community, only male heirs may inherit family lands. Single women work on family land. When a woman gets married, she works on the lands of her husband. Her interest in the land of her husband lasts for the duration of the marriage. If the husband should die, his wife may be granted a temporary land tutorship role in order to preserve the rights of her children to the land. However, it often occurs that her husband's brothers inherit the land. Customary laws provide that whomever inherits the land preserves the livelihoods of widows and orphans. This might be accomplished by allocating certain rights to the family of the deceased to some agricultural plots to ensure their subsistence. However, the fact remains that women are entirely dependent on male members of their families or on the willingness of the community for access to land.

Land Rights of Non-Citizens of Côte d'Ivoire

Article 1 of Act 98-750 states that "only the state of Côte d'Ivoire, local authorities and individuals are allowed to own land." Non-citizens of Côte d'Ivoire can only obtain access to land through a lease or a long-lease agreement. In effect, a non-citizens of Côte d'Ivoire who purchases land according to customary practice cannot see their purchase converted into a property title under current legislation. At best, foreign individuals or companies may acquire long-lease contracts at favourable terms. Non-Côte d'Ivoire-Beneficiaries of a customary assignment can request a long-lease agreement certification as part of a land certification application process. In this case, the law requires the applicant to prove "a continuous and peaceful existence of customary rights".

The long-lease contract does not equate to a property title on land, but offers long-term guarantees to encourage investment (e.g., in the form of profitable plantations). The lease itself is transferable and is recognised as a valuable asset by most lenders. The duration of the long-lease extends from a minimum of 18 to 99 years and is transmissible to heirs. The lessee is required to develop the land value. In return, the rent is relatively low. These rents are controlled in order to avoid excessive disparities in prices. It is essential that these amounts are modest, especially in the case of non- Côte d'Ivoire-farmers who do not have access to land certificates but might have invested in growing plantations for decades and would not accept high rental fees on top of their initial investment of effort.

Act No.98-750 allows for the preservation of land titles acquired by non-Côte d'Ivoire legal and natural persons prior to 1998. A 2004 Amendment to the 1998 Law (No. 2004-

414) provides that these titles may be transferred to legitimate heirs, even if these heirs do not themselves fulfill the conditions of access provided by the 1998 law. However, as only 1-2% of rural land is registered, these provisions affect only a small number of cases.

Land Conflict Settlement Mechanisms

The vast majority of rural land disputes are resolved by customary authorities, which have the advantage of proximity and effectiveness. Customary rulings are widely respected in spite of growing doubts about their legitimacy. The customary process has the additional advantage of being significantly more affordable than legal proceedings. At the same time, the method of recourse to customary authorities can vary from one village to the next depending on the influence of the leaders in question and in light of local power relations structures.

The village leader responsible for finding solutions to land disputes is often a representative of one of the village's prominent land-owning families and enjoys the support of notable community members. Village chiefs often have little authority over land per se, but may enjoy a form of pre-eminence as arbitrators of disputes. The village leader may also be the land chief; otherwise the land chief is generally present among notable citizens. While it is the village chief's role to pass judgement on the dispute, it is more often incumbent on the land chief and other notables, as custodians of tradition, to make inquiries and establish the nature and existence of customary rights.

2.4 Administrative Structure

2.4.1 Ministry of Mines and Industry

Mining activities in Côte d'Ivoire fall under the jurisdiction of the General Directorate of Mines and Geology, which forms part of the Ministry of Mines and Industry. Applications for mining and exploration licences have to be approved by this entity.

This Ministry implements the industrialisation policy of Côte d'Ivoire and helps to develop the private sector. The Ministry is the primary contact for mining companies and provides guidance to project proponents in relation to the regulatory framework for mining activities and co-ordination with other authorities and organisations in the country. It is responsible for the following, *inter alia*:

- Issuance and successive renewals of mining titles, licences for exploration and operation;
- Granting of permissions and successive renewals for artisanal gold and diamond exploration, exploration and operation of quarries for sand and construction materials;
- Sales of precious metals, export; and

- Import and use of explosive substances.

The authority directly relevant to the Project is the General Directorate of Mines and Geology. It develops and coordinates the implementation of the national policy on mines. It deals, among other things, with the various requests for authorisation and mining titles, and the control and monitoring of mining exploration and exploitation activities, and is responsible for the development, the continuous updates of the geological mapping of the country, and approval for the transportation and storage of cyanide and explosives.

The General Directorate of Mines and Geology is structured into the following units:

- 4 Directorates:
    - The Directorate of the Mapping and Geological Prospecting (DCPG);
    - The Directorate of Mining Development (DDM);
    - The Directorate of Small-Scale Artisanal Mining and Quarries (DEMAC);
    - The Directorate of Mining Information and Cadastral (DIMCM).
- 1 Relating Service:
    - Technical Controls Service.

For this Project, the relevant unit is the Directorate of Mining Development, which shall submit, after arriving at a favourable technical opinion by the General Directorate of Mines and Geology, the request for authorisation of mine operation to the Minister in accordance with article 83 of Decree No. 2014-397 of 25 June 2014, Laying Down the Procedure for the Application of the Law No. 2014-138 of 24 March 2014 on the Mining Code.

2.4.2 Ministry of the Environment and Sustainable Development

The Ministry of the Environment and Sustainable Development is the leading institutions in charge of environmental protection, leaving conditions, sustainable development and monitoring policy of Côte d'Ivoire. Apart from the cabinet, the relating directions and services, the Ministry includes two General Directions namely General Direction of Environment and General Direction of Sustainable Development.

- **General Direction of Environment includes the following:**
    - The Direction of Ecology and Nature Protection (DEPN);
    - The Direction of Environmental Quality and Risques Prevention (DQEPR);
    - The Direction of Infrastructures and Environmental Technology (DITE).

- **General Direction of Sustainable Development includes the following:**
  - The Direction of Policies and Strategies (DPS);
  - The Direction of Normes and Sustainable Development Promotion (DNPDD);
  - The Direction of Green Economy and Social Responsibility (DEVRS).

The missions of these two General Directions include but not limited (those relating to the project):

- **General Direction of Environment missions include the following:**
  - Coordon the activities of other Administratives Directions in relation with its authority;
  - Planning and control the Environmental Policy;
  - Assure the ecological rational management of the envvironemental matrix and Nature Protection;
  - Preserve the quality of the environment;
  - Promote the environmental Infrastructures and technologies;
  - Enhance the promotion and implementation of environmental international conventions endorsed by Côte d'Ivoire;
  - Organise the national two weeks environmental festivals;
  - Coordonne the relating external services such as Regional Directions.
- **General Direction of Sustainable Development missions include the following:**
  - Coordon the activities of other Administratives Directions in relation with its authority;
  - Ensure the intégration of sustainable development principles into sectorial policies and assure the follow up;
  - Planning and control the sutainable development, climate changes, biodiversity safeguarding and water resources protection strategies;
  - Promote green economy, responsible production and consumption;

- Promote sustainable development into all national socio-economical organismes.

The structures under the supervision of this Ministry likely to be involved in this project are the National Environmental Agency (ANDE), and the Anti-Pollution Centre (CIAPOL) of Côte d'Ivoire.

ANDE, established by Decree No. 97-373 of 02 July 1997, is responsible, *inter alia*, for the following:

- Coordination of the implementation of environmental development, the integration of environmental concerns in development projects and programmes;
- Establishment and management of a national system of environmental information;
- Implementation of the procedure of impact assessment and the assessment of the environmental impact of macroeconomic policies;
- Implementation of international conventions and treaties in the field of the environment; and
- Establishment of relationships with NGO networks.

ANDE includes the Environmental Impact Assessment Office (BEIE) whose duties established by Article 11 of Decree No. 96-894 of 8 November 1996 are among others:

- Technical assistance to the different organisations involved in the protection of the environment, including Government, regulatory authorities, NGOs and other development partners (engineering firms, private companies, donors, etc.);
- Assessment and record-keeping of Impact and Environmental Impact Studies for approval or licensing, under the seal of the Minister in charge of the Environment;
- Audit and monitoring of measures recommended by the Environmental Impact Assessment;
- Organisation of public inquiries, co-ordination with other agencies and organisations concerned; and
- Distribution of information related to the Environmental Impact Assessment.

CIAPOL, established by the Decree No. 91-662 of 9 October 1991, has the following responsibilities and tasks, *inter alia*:

- Combat pollution and prevent risks and nuisances caused by economic activities, whether industrial or agricultural, by applying the environmental protection legislation and regulations,
- Participate in the assessment of the ecological quality of water and air, and
- Implement the general control of industrial pollution sources.
- Reduce industrial pollution from industrial activities;
- Minimise environmental and safety risks to workers and the general public;
- Ensure a rational use of raw materials used in production processes, especially in relation to water resources;
- Promote the use of low-waste technologies and promote the valorisation of by-products and industrial waste; and
- Conduct of inspections on project sites.

2.4.3 Ministry of Construction and Urbanism

The Ministry of Construction and Urbanism with the Planning Branch in the Directorate of Construction and Housing promotes construction standards. This Department ensures compliance with the legislation of Côte d'Ivoire on resettlement and urban land expropriation as well as the protection of sensible zones. It is responsible for the supervision of the construction works in resettlement areas and ensures that construction standards for new houses are respected.

2.4.4 Ministry of Economic Infrastructure

The Ministry of Economic Infrastructure with the General Directorate of Water Supply and the National Potable Drinking Water Agency (ONEP) ensures the control, protection and monitoring of water resources that could be used for the production of drinking water.

The Roads Management Agency (AGEROUTE) sub-structure under the Ministry is responsible for the construction and monitoring of the road network in the country.

As this Project will require the re-alignment of road infrastructure, the Direction of Road Infrastructure (DIR) should be involved in the design and the realisation of the related project components.

The relating structures of the ministry which will be involved in the project are *inter alia* :

- **The Housing and Civil Works Laboratory (LBTP)**.

Its main missions are as follow:

- Provide expertise to technical consulting groups by providing data relating to soil quality for the design of roads, bridges, airports, seaports, railwails and housing;
- Conduct soil studies to determine appropriate housing foundation for sustainable buildings;
- Assure the security of elctrics, industrial equipments, and low energy consumtion housing infrastructures;
- Contribute to te development of new efficient building material;
- Contribute to transport infrastructures modernization;
- Train on quality control techniques.

- **L'Agence de Gestion des Routes (AGEROUTE)**

Its main objective is to provide support and assistance to the State to achieve is mission relating to the management of roads network under his control. During the execution of assistance mission of Master of Work or delegate Master of Work as instructed by the State, the Agency is in charge of the following:

- The preparation and executiin of planning tasks;
- The preparation of the request for proposal (RFP) relating to the roads construction;
- The follow up of the roads construction works;
- The monitoring othe road network;
- Set up and management of road database or BDR (Banques de Données Routières);
- And capacity building.

In the case of road insfrastructure re-alignement by the project, the direction of Road Infrastructure must be involved in the design and the completion of project's road component.

2.4.5 Ministry of Water and Forests

The Ministry of Water and Forests is responsible for the implementation and monitoring of the Government's policy on protection of water and the forest. Its responsibilities include, *inter alia*, the following (selection of points relevant to this Project):

- Sustainable management of forests, fauna and flora:
  - Promotion of sustainable operations for forest resources;
  - Definition and implementation of the national reforestation plan;

    - Implementation of national policies for the sustainable management of wildlife and its rational use in conjunction with the Minister of Environment;

- Sustainable water management and water protection:
    - Implementation of the Water Code with the Ministry of Economic Infrastructure, Ministry of Environment and Ministry of Agriculture and Ministry for Animal Resources and Fishery;

- Protection of fauna and flora:
    - Ensuring the integrity of the forests;
    - Implementation of conventions and treaties in the field of the protection of fauna and flora; and
    - Protection of soils and waters in association with the Ministry of Agriculture and Ministry for Animal Resources and Fishery.

2.4.6 Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy amongst others provides approval for the storage of hydrocarbons. It also permits volumes to be stored. The Ministry furthermore has the right to inspect any operation where hydrocarbons are stored to ensure that it stored in such a manner as not to harm the environment.

2.4.7 Ministry of Employment and Social Affairs

The Ministry of Employment and Social Affairs is responsible for the implementation and monitoring of the Government policy on employment, the fight against poverty and social development. It will be involved in the Project due economic and social challenges, the creation of jobs for the local residents, and improvement of the living conditions.

The structures under its responsibility which are relevant for the project are as follow :

- **The Nationale Social Security Agency (CNPS)**

The Agency manages the compulsory pension scheme of the social security of private sector and assilitated. It intervenes also in the area of sanitation and social.

- **Labour Inspection**

The role of the Labour Inspection is to :

- Control the compliance of labour legislation, regulation, job and social security ;

- Advise the parties and arbitrate the individual conflicts and employer-employees conclicts ;
- Monitor the compliance of occupational health regulations.

2.4.8 Ministry of Transport

The Ministry of transport is responsible for transport infrastructure, to ensure the monitoring and implementation of action plans and policies to promote infrastructure and to ensure road safety the Office of Road Safety (OSER). The sub-directorate specifically responsible for road construction is the Direction of Road Infrastructure (DRI).

OSER was created by Law N° 78-661 of 4 August 1978, as a national public administrative institution, with delegated legal power and financial autonomy. It aims to enhance road safety.

For the purpose of the Project, approval will have to be obtained from DRI, OSER and the Ministry of Transport for the upgrade of the main access road and the realignment of the road section between Allahou-Bazi to Kouakougnanou.

2.4.9 Ministry of the Interior and Security

The Ministry of the Interior and Security with its devolved and decentralised entities (Prefecture of Bouaflé, sub-prefecture of Bouaflé, Town hall of Bouaflé) ensure the involvement of local authorities and communities living in the project area in local development actions developed by the Project.

Article 1 of the Law No. 2003-208 of 7 July 2003 on the Transfer and Allocation of Powers from the State to Regional Authorities stipulates that "local authorities work together with the State for the economic, social, health, educational, cultural and scientific development of the population and, in general, for the improvement of their living environment. To this end, they have general jurisdiction and special powers conferred by laws and regulations."

The Yaoure Project is located in the Sub-Prefecture of Bouaflé which is empowered by this law to carry out inspections of the Project site.

The local authorities are responsible for:

- Regional planning;
- Development planning;
- Urbanisation and housing;
- Communication networks;

- Public transport;
- Public health and hygiene;
- Protection of the environment and management of natural resources;
- Safety and civil protection;
- Education, professional and technical training;
- Culture, sports and recreation;
- Promotion of economic development and employment;
- The promotion of tourism;
- Water supply, sanitation and electric power supply;
- Promote family, youth, women, children, the disabled and the elderly.

2.5 Local Governance and Law

This Section identifies major trends in the devolution of power and decentralisation of the government in Côte d'Ivoire from independence to the present and the various levels of government that claim administrative authority in the Study Area.

2.5.1 Introduction

Local governance is defined as the system by which local authorities, whether traditional or established by modern statutes, govern local social and property relations, economies, public infrastructure and other local public resources. To understand the current local governance system, this Section offers a brief description of the evolution of local administration in Côte d'Ivoire.

As in most African countries, the local governance system of Côte d'Ivoire is characterised by the coexistence of traditional authorities - embodied in a chiefdom – and modern administrative power inherited from the colonial power in the form of law-making authority and the ability to enforce those laws. Traditional authority is most pronounced at the local, or, village, level.

A series of reforms occurring between the late colonial period and the present has resulted in the creation of several new levels of government, some of which can name predecessors from the colonial period. Currently the political jurisdictions in Côte d'Ivoire are divided as follows: national government, districts, regions, departments, sub-prefectures, and municipalities (townships, sectors, villages and village communities). Each level of government possesses limited legislative responsibilities covering several areas of social and economic concern.

The gradual devolution of powers from the national government to new lower levels of government was a response to several issues related to governance, including a general inability by the national government in the later part of the 20th century to carry out integrated development programmes and a growing desire on part of the public for greater freedom of expression and access to democratic decision-making processes. Decentralisation, then, sought to achieve greater public participation in the management of local affairs, make local administration more efficient and responsive, and encourage a better balance of economic growth across the regions, particularly in rural areas experiencing severe levels of outmigration.

However, several important governance issues remain: local boundaries often disregard areas of cultural, social, and ethnic homogeneity; lower levels of government are often unable to live up to their enhanced responsibilities owing to chronic underfunding; public officials sometimes lack the training to face the complexity and delicacy of administering local development; and, a lack of public awareness and high illiteracy rates continue to limit public participation in local politics.

2.5.2 Administrative Bodies

Since 1980, the Government of Côte d'Ivoire has embarked on a process of decentralisation through the municipalisation of the country and the creation of new supra-municipal communities. In 2000, a new decentralisation policy further broadened and deepened the boundaries of local governance. In 2001, the National Assembly enacted laws that resulted in local governance structures - Departments and Districts in particular – gaining a higher level of autonomy.

What follows in this Section is a description of the levels of government that operate within the settlements of the Study Area. A more detailed discussion on this topic can be found on Section 5.

<u>Districts</u>

Côte d'Ivoire is divided into 14 districts, 2 of which are autonomous. A district's mission include: driving major supra-regional development projects; ensuring balanced and major investments of state programmes throughout the territory in order to address regional disparities and minimise regional particularities. Districts are administered by a Governor appointed by Council of Ministers.

The Study Area spans the Districts of Yamoussoukro and Sassandra-Marahoué. Their capitals are Yamoussoukro and Daloa, respectively.

<u>Regions</u>

The Region is the intermediate level between the district and the department. Regions are responsible for the design, programming, harmonisation, support, coordination and control of the social, cultural and economic operations conducted by the state in a certain area. The region generally includes several departments. A regional Prefect appointed by the Council of Ministers administers the region. The Prefect embodies executive power in the region.

The Yaoure gold project is situated between the region of Marahoué (in the District of Sassandra-Marahoué) and the region of Belier (in the District of Yamoussoukro). The Marahoué region is sub-divided into three departments: Zuenoula, Bouaflé and Sinfra. The Autonomous District of Yamoussoukro is composed of two divisions: Yamoussoukro and Attiégouakro.

Departments

The department is the relay stage between the region and the sub-prefecture. It is administered by a Departmental Prefect appointed by the Council of Ministers. The prefect is responsible for:

- Ensuring the implementation of laws, regulations and executive decisions;
- Directing, managing, coordinating and controlling the activities of administrative and technical services;
- Managing public officials under his authority;
- Overseeing public order, security and safety in the department;
- Assigning funds from the state budget, including funds assigned by the ministers for the benefit of departmental services of the regional delegations;
- Monitoring development activities of the department and harmonising the actions of the state with those of local communities; and
- Exercising supervision and control of local authorities within its jurisdiction in accordance with laws and regulations.

The Project spans the Departments of Bouaflé and Yamoussoukro. The Department of Bouaflé includes seven 7 sub-prefectures, Bouaflé, Tibéita, Bonon, N'douffoukankro, Zaguiéta, Pakouabo and Bégbessou. The department of Yamoussoukro includes 2 sub-prefectures, Yamoussoukro and Koussou.

Sub-Prefectures

The sub-prefecture is an intermediate administrative level between the departments and a group of villages. The sub-prefecture is managed by a sub-prefect appointed by the Council of Ministers. A sub-prefect is the representative of the central administration and acts under the supervision of the departmental prefect. The sub-prefect supervises the work of village leaders on issues related to land management.

The Study Area of the project spans the sub-prefectures of Bouaflé and Bégbessou (in the Marahoué Region) and Koussou (in the Belier Region). The sub-prefecture of Bégbessou is not fully established. As such, communities in the Bégbessou sub-prefectures are temporarily administered by the sub-prefecture of Bouaflé.

Townships and Sectors

A township or sector consists of several villages under the authority of a leader/chief who is normally based in one of the villages of the township (usually referred to as a "chef canton" or township chief). The village housing the regional chieftaincy is the center of the political and administrative organisation of the township/sector. The authority of a chef canton varies considerably from township to township. Surveys from the Study Area indicate that townships and sectors have only a marginal influence in the local governance process.

The Project affects the Yaoure North and South townships:

- Bégbessou township in the north with the villages of Bégbessou, Semimbo, Diallé Koubi, Kami, N'Da Koffi Yobouekro, Akakro, Angovia and Allahu-Bazi; and

- Bozi township in the south with the villages of Bozi, Alley, Kouakougnanou, Zougoussou, Gourgui, Alekran, Patizia, Yoho, Tuankro, Zegata, Allanikro and N'Gorankro.

Villages and Village Committees

- Under section 39 of Ordinance No. 2011-262 of 28 September 2011, the village is considered the basic administrative unit of the country. The village is defined as a territory occupied by people bound together by common ancestors or a common lineage.

- Villages may be created by a group of families coming together in spontaneous association or at the request of authorities. Some villages are the result of a merger of multiple camps, neighbourhoods and other residential areas. Villages are administered by a village chief assisted by a village council of public figures ("notables" or "cadres"). Other relevant public figures in the governance structure of a village include: traditional chiefs of land and cultural heritage sites, representatives of neighbourhoods or minority communities, such as immigrants, and representatives of socio-economic categories, such as women, local youth, and agricultural leagues and associations. The village chief and council are usually chosen according to tradition. Village leadership is responsible for the daily management of village life.

- The villages affected by the Yaoure Project have been identified according to the methodology described in the "Survey of Priority Villages by Level of Impact" segment in Section 6.11.2.4.

Municipalities

Municipalities are local authorities with elected governments. They normally include a number of neighbourhoods or villages. Three municipal authorities are recognised under Article 46 of Ordinance No. 2011-262 of 28 September 2011:

- The City Council;
- The Mayor; and
- The Municipality.

The City Council is the legislative body of the municipality. The City Council meets at least quarterly, but it may be convened by the Mayor whenever he deems appropriate, by request of a majority of councillors, or by order of the supervising level of government. The Council has general jurisdiction over the affairs of the Municipality. Among its main functions, the Council:

- Votes on the municipal budget;
- Deliberates on municipal accounts;
- Decides on the remuneration and salary of the staff;
- Establishes police regulations, administration and those relating to taxes;
- Authorises municipal contracts;
- Decides on buildings and civil works;
- Creates and deletes communal services;
- Takes decisions to acquire shares or bonds in companies responsible for running municipal services; and
- Designates members to serve on boards of municipal companies, commissions and agencies in which the Municipality must be represented as established by the law.

The Mayor is elected by the municipal councillors to a five-year term during the first meeting of the city council. The Mayor of a city has a dual role as the representative of the central authority to the council and as the executive authority of the Municipality.

As an elected officer representing a local governance body, the Mayor is responsible for:

- Implementing the deliberations of the city council;
- Chairing the Council and the Municipality;
- Ensuring the publication of the council proceedings;
- Ensuring the enforcement of police regulations;
- Preparing the budget and authorising the expenditures and revenues of the Municipality;
- Heading the municipal administration and staff;
- Maintaining order (safety, security and public health);
- Representing the Municipality to justice; and
- Ensuring the protection of the environment.

Under the authority of the departmental prefect, the Mayor is responsible for:

- The publication and implementation of laws and regulations;
- The execution of general security measures; and
- The implementation of the economic, social and cultural policies as defined by the Government.

The role of the Municipality is set out in Decree No. 83-154 of 2 March 1983 determining the operating rules of the municipalities and the city of Abidjan. Law No. 80-1180 establishes that a Municipality is responsible for:

- Establishing the agenda of board meetings;
- Coordinating municipal development actions;
- Monitoring the collection of taxes;
- Reviewing the monthly and quarterly statements of budget execution;
- Monitoring the implementation of the decisions of the City Council;
- Preparing the three-year development programme;
- Determining the mode of implementation of communal work; and

- Supervising the tendering process for the procurement of regional services.

The department of Bouaflé comprises 2 municipalities, Bouaflé and Bonon.

Table 2-4 The devolution system in the Study Area (Source 2D Consulting, 2015)

Type	Name	Type of Decentralisation	Legislative Body	Executive Body	Designation Mode	Tutorship
Districts	District de Sassandra-Marahoué et District autonome de Yamoussoukro	Deconcentration	District Council	Governor of the District	The Governor is appointed by the Council of Ministers	Ministry of Local and Regional Affairs
Regions	Région de la Marahoué Région du Bélier	Devolution	Regional Council	President of the Regional Council	Local populations elect the Regional Council (the president is appointed by councillors)	Prefect of the Region
	Région de la Marahoué Région du Bélier	Deconcentration	/	Prefect of the Region	The Prefect is appointed by the Council of Ministers	Ministry of Local and Regional Affairs
Departements	Département de Bouaflé Département de Yamoussoukro	Deconcentration	None	Prefect of the Department	The Prefect is appointed by the Council of Ministers	Prefect of the Region
Sub-prefectures	Sous-préfecture de Bégbessou Sous-Préfecture de Bouaflé Sous-préfecture de Kossou	Deconcentration	None	Sub-Prefect	The Sub-Prefect is appointed by the Council of Ministers	Prefet of the Region
Villages (Area of Local Direct Influence)	Akakro Allahou-Bazi Angovia N'Dakoffiyobouekro Kouakougnanou	Deconcentration	Village Council	Village Chief	Depends on the Village	Sub-Prefect

2.6 The ESIA and Permitting Process in Côte d'Ivoire

The overarching legal framework for ESIA in Côte d'Ivoire is Act No. 96-766 of 3 October 1996. The Act forms the framework ESIA legislation and defines the administrative process as well as the content requirements for ESIA.

The Ministry of Environment is the administrative authority responsible for overseeing and reviewing the ESIA. The Ministry convenes the National Agency of Environment (ANDE) consisting of representatives of the main Ministries. ANDE is responsible for:

- Compilation of the ToR for ESIA;
- The review of the ESIA documentation for the Project; and
- Ultimately for the environmental approval for the Project in the form of a Decree.

According to Decree No. 96-894 dated 08 November 1996 The ESIA process consists of the following stages:

1. ESIA application and implementation stage
    - The project proponent, sponsor of the Environmental and Social Impact Assessment (ESIA), shall submit a description of its project to ANDE to apply for the development of the ToR of the ESIA;
    - In accordance with Article 11, paragraph 2, of Decree No. 96-894, ANDE is responsible for drawing up of the ESIA ToR. On the basis of the description of the project and a reconnaissance visit to the project site, it draws-up the ToR and provides it to the project proponent for further action. In the case of the Yaoure project, Perseus agreed with ANDE that AMEC should draw up the ToR and submit them to ANDE for approval, in order to incorporate international best practice such as the IFC PS.
    - The project proponent appoints an environmental/social consultancy (Amec Foster Wheeler, 2D, rePlan) to carry out the ESIA process and prepare the ESIA Report. The ESIA report is submitted to ANDE in 20 hard copies.
2. Review of the ESIA by ANDE
    - A site reconnaissance visit is organised by ANDE to understand the environmental and social aspects first hand, and to assess the compliance of the state of the project site in relation to the content of the ESIA report.

- Public hearings will take place to gather appreciations, suggestions and counter-proposals of the impacted communities and other stakeholders, allowing ANDE to have at its disposal all information necessary for taking a decision (Article 16 of Decree No. 96-894);

- Evaluation process to assess the technical and social impacts of the project. This is organised by a meeting of an inter-ministerial committee convened by ANDE. In this analysis, experts from public and/or private institutions may be involved, as selected by ANDE;

3. Approval of the ESIA report. In accordance with articles 4 and 14 of Decree No. 96-894, the approval process has the following phases:

    - Formal acceptance of the ESIA report: following the technical evaluation, ANDE notifies the proponent, through the validation report, of the formal acceptability of the ESIA report;

    - Issuance of a Ministerial Decree of Approval of the ESIA: in accordance with article 14 of Decree No. 96-894, the approval decision shall be notified to the proponent by an order signed by the Minister in charge of the environment.

4. Follow up: ANDE will regularly assess the implementation and completion of the mitigation measures described in the ESIA and the ESMS. To do so, audits and inspections are carried out respectively by the enterprise itself and ANDE.

The required content of the ESIA follows Art. 40 of the Act No. 96-766 and was summarised in Section 1.5 of this Report and is not repeated here for brevity.

Only when an ESIA has been approved can the Ministry of Mines and Industry approve a Mining Licence.

The National Anti-pollution Centre (CIAPOL), through the Ministry of Environment, will issue a decree in which air, noise, soil and water quality limits will be stipulated for the Project.

Additional approvals which may be required for the Project include, but may not be limited to, an authorisation for the abstraction and use of ground and surface water by the Directorate of Water Resources and Forestry.

2.7 International Obligations of Côte d'Ivoire

Côte d'Ivoire is a member or signatory to a large number of international conventions and treaties in the field of environmental protection that are listed in **Error! Reference source not found.**. The following table summarises those international obligations that are directly relevant to the Project.

Table 2-5 Treaties and Conventions to which Cote d'Ivoire is a Signatory

Treaty	Signatory Date / Ratification Date
Hague convention for the Protection of Cultural Property, 1954 Second Hague Protocol for the Protection of Cultural Property, 1999	24 January 1980 17 May 1999
Convention concerning the protection of the world cultural and natural heritage, 1972 (UNESCO)	9 January 1981
African Charter of Human and Peoples Rights, African Union, 1981	22 January 1992
African Convention on the conservation of nature and natural resources, 2003	27 February 2004
Montreal Protocol on substances that deplete the ozone layer (and the amendments thereto), 1990, 1992, 1997, 1999	30 June 2012
Bamako Convention on the ban of the import into Africa and the control of trans-boundary movements of hazardous waste within Africa, 1991	16 September 1994
Basel Convention on the control of trans-boundary movements of hazardous waste and their disposal, 1989	1 December 1994
Constitution of the Food and Agriculture Organisation (FAO),1945	9 November 1961
Convention on biological diversity, 1992	20 November 1994
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973	21 November 1994
Convention on the conservation of migratory species of wild animals, 1979	1 April 2003
Convention (and Amendment) on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar convention) (As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987),1971	27 January 1996
International Plant Protection Convention, 1997	2 October 2005
International Tropical Timber Agreement (2006)	31 October 2008
Kyoto protocol to the United Nations framework convention on climate change, 1997	23 April 2007
Montreal Protocol on substances that deplete the ozone layer as either adjusted and/or amended in London 1990 Copenhagen 1992 Vienna 1995 Montreal 1997 Beijing 1999, 1987	5 April 1993
United Nations framework Convention on climate change, Rio de Janeiro, 1992	29 November 1994
International Health Regulations, 2005	15 June 2007
International Plant Protection Convention, 1997	17 December 2004
London Convention on the conservation of fauna and flora in its natural state (1933)	31 May 1938

2.8 Relevant International Guidelines

2.8.1 Equator Principles

The Equator Principles are a financial industry benchmark for determining, assessing and managing social and environmental risks to Projects. There is close alignment between the Equator Principles, World Bank Group Polices, Safeguards and the International Finance Corporation (IFC) Standards and Guidelines.

The revised Equator Principles address the following:

- Principle 1: Review and Categorisation;
- Principle 2: Social and Environmental Assessment;

- Principle 3: Applicable Social and Environmental Assessment;
- Principle 4: Action Plan and Management System;
- Principle 5: Consultation and Disclosure;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Equator Principles Financial Institutions Reporting.

Projects are categorised based on the magnitude of the potential social or environmental impacts and risks of that Project, in accordance with World Bank Group classification criteria. These categories are:

- Category A: Projects with potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented;
- Category B: Projects with limited adverse social or environmental impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and
- Category C: Projects with minimal or no social or environmental impacts.

Mining Projects, by their extractive nature, tend to fall into Categories A or B, being high or medium risk. The Yaoure Project falls under Category A.

For Category A and B Projects, the borrower must conduct a social and environmental assessment to determine the social and environmental impacts and risks of the Project, and to propose relevant and appropriate mitigation and management measures in respect of the Project.

2.8.2 World Bank Group Standards and Guidance Notes

In 2006 the IFC put together a set of eight Performance Standards to be used to identify, assess, manage and monitor risk for proposed development Projects. The standards have been revised and as from January 2012 the revised standards are in effect. The 2012 edition puts an even greater emphasis on social and ecological considerations in the assessment of Project developments.

Performance Standard (PS) 1 addresses the social and environmental assessment and management systems. The primary objectives of PS 1 are as follows:

- Identify and assess social and environment impacts, both adverse and beneficial, in the Project's area of influence;
- To avoid, or where avoidance is not possible, minimise, mitigate or compensate for adverse impacts on workers, affected communities, and the environment;
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them; and
- To promote improved social and environmental performance of companies through the effective use of management systems.

Performance Standard (PS) 2 addresses labour and working conditions. The primary objectives of PS 2 are as follows:

- Establish, maintain, and improve the worker-management relationship;
- Promote the fair treatment, non-discrimination and equal opportunity of workers, and compliance with national labour and employment laws;
- Protect the workforce by addressing child labour and forced labour;
- Promote safe and healthy working conditions; and
- Protect and promote the health of workers.

Performance Standard (PS) 3 addresses pollution prevention and abatement. The primary objectives of PS 3 are as follows:

- Avoid or minimise adverse impacts on human health and the environment by avoiding or minimising pollution from Project activities; and
- Promote the reduction of emissions that contribute to climate change.

Performance Standard (PS) 4 addresses community health, safety and security. The primary objectives of PS 4 are as follows:

- Avoid or minimise risks to and impacts on the health and safety of the local community during the Project lifecycle from both routine and non-routine circumstances; and
- Ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimises risks to the community's safety and security.

Performance Standard (PS) 5 addresses land acquisition and involuntary resettlement. The primary objectives of PS 5 are as follows:

- Avoid or at least minimise involuntary resettlement wherever feasible by exploring alternative Project designs and layouts;
- Mitigate adverse social and economic impacts from land requisition or restrictions on affected persons' use of land by (i) providing compensation for loss of assets at replacement cost; and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation and the informed participation of those affected;
- Improve or at least restore the livelihoods and standards of living of displaced persons; and
- Improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

Performance Standard (PS) 6 addresses biodiversity conservation and sustainable natural resource management. The primary objectives of PS 6 are as follows:

- Protect and conserve biodiversity including following the mitigation hierarchy, identification of ecological zones and identification of important areas supporting threatened species;
- To maintain the benefits from ecosystem services valued by people and businesses; and
- Promote the sustainable management and use of natural resources through the adoption of practices that integrate conservation needs and development priorities.

Performance Standard (PS) 7 addresses indigenous peoples. The primary objectives of PS 7 are as follows:

- Seeks to ensure that indigenous peoples participate in their own development, and that their cultural practises are protected and respected;
- Identify through a social impact assessment the presence and impacts of the Project on indigenous peoples; and
- If negative impacts on indigenous peoples are unavoidable, indigenous people must be properly consulted and compensated in a culturally sensitive manner.

No indigenous peoples are present in the Project area and as such, PS 7 does **not** apply to the Yaoure Project.

Performance Standard (PS) 8 addresses cultural heritage. The primary objectives of PS 8 are as follows:

- Protect cultural heritage from adverse impacts of Project activities and support its preservation; and
- Promote the equitable sharing of benefits from the use of cultural heritage in business activities.

2.8.3 IFC and World Bank Environmental, Health and Safety Guidelines

The IFC's Environmental, Health, and Safety (EHS) Guidelines are technical references with general and industry-specific examples of good international industry practice (also referred to GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines document, which provides guidance to users on common EHS issues potentially applicable in the mining sector. The EHS guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs.

World Bank Environmental and Social Safeguard Policies and Procedures that are relevant for the Yaoure Project include:

- IFC General Environmental, Health and Safety (EHS) Guidelines (2007);
- IFC EHS Guidelines for Mining (2007);
- IFC EHS Guidelines for Water and Sanitation (2007);
- IFC EHS Guidelines for Waste Management (2007); and
- IFC Stakeholder Engagement: Good Practice Handbook for Companies Doing Business in Emerging Markets (2007).

2.8.4 African Development Bank (AfDB)

The African Development Bank (AfDB), headquartered in Abijan, Côte d'Ivoire, is a regional multilateral development finance institution. It is engaged in mobilising resources towards the economic and social progress of its Regional Member Countries (RMCs). Côte d'Ivoire is a Member Country.

The AfDB's mission is to promote economic and social development through loans, equity, investments and technical assistance. Currently, the Combined 2013-2017 Country Strategy is in force.

The AfDB has the following policies in place:

- Policy on Poverty Reduction;
- Policy on the Environment;
- Involuntary Resettlement Policy;
- Gender Policy; and
- Population Policy.

The AfDB perspective on environmentally sustainable development in Africa is described in the 2004 Bank Group Policy on the Environment. The Policy acknowledges the need to preserve and enhance ecological capital to sustain and enrich economic growth in Africa. The main goals of the Policy are to:

- Promote a long-term view and perspective of economic and social development;
- Reverse, where possible, and halt the impoverishment process in Africa by enhancing the access of the poor to environmental resources;
- Help Regional Member Countries to build their human capacity and sensitise policymakers on environmental issues and bring about institutional changes to achieve sustainable development; and
- Reinforce the existing partnerships with international institutions and network also with regional and sub regional organisations to coordinate interventions in environmentally sustainable development.

The AfDB has two procedural guidelines central to their Policy on the Environment (2004), namely the Bank Group's Guidelines for Strategic Impact Assessment (2003a) and the Integrated Environmental and Social Impact Assessment Guidelines (IESIA) (2003b). Strategic Impact Assessment is a systematic process of evaluating the environmental consequences of any proposed policy or programme, as well as a tool for assessing social and environmental sustainability of policy-based lending, structural adjustment, and sector investment lending. The IESIA Guidelines are designed to ensure the inclusion of environmental and social issues in Bank Projects throughout the Project cycle. These provide guidelines for sector-specific issues and impacts that should be taken into account during the preparation and assessment phases of a Project.

The companion documents to the IESIA Guidelines are:

- Environmental and Social Assessment Procedures for Public Sector Operations (2001);

- Environmental Review Procedures for Private Sector Operations (2001);
- Handbook on Stakeholder Consultation and Participation (2001); and
- AfDB's Policies on Involuntary Resettlement (2003) and Environment (2004).

These documents provide the procedural process by which Projects are categorised and assessed.

2.8.5 International Council on Metals and Mining

The ICMM has issued a series of guidance documents, the most relevant of which are listed in the following:

- Good Practice Guidance for Mining and Biodiversity (2006);
- Planning for Integrated Mine Closure: Toolkit (2008);
- Guidance Paper on Financial Assurance for Mine Closure and Reclamation (2006);
- Good Practice in Emergency Preparedness and Response (2005);
- Good Practice Guidance on Occupational Health Risk Assessment (2009);
- Good Practice Guidance on Health Impact Assessment (2010);
- Health Risk Assessment Guidance for Metals (2007);
- MERAG: Metals Environmental Risk Assessment Guidance (2007);
- Ores and Concentrates - An industry approach to EU Hazard Classification (2007);
- Community Development Toolkit (2005);
- Handling and Resolving Local Level Concerns & Grievances (2009);
- Human Rights in the Mining & Metals Industry – Overview, Management Approach and Issues (2009);
- Adapting to a changing climate: implications for the mining and metals industry (2013);
- Independent report on biodiversity offsets (2013); and

- A practical guide to catchment-based water management for the mining and metals industry (2014).

2.8.6 International Cyanide Management Code

The International Cyanide Management Code (July 2012) (the Cyanide Code or the Code) is a voluntary initiative for the gold mining industry and the producers and transporters of the cyanide used in gold mining. The purpose of the Cynaide Code is to improve the management of cyanide used in gold mining and assist in the protection of human health and the reduction of environmental impacts. Mining companies that adopt the Code must have their operations that use cyanide audited by an independent third party to determine the status of Code implementation. Those operations that meet the Code requirements can be certified. Audit results are made public to inform stakeholders of the status of cyanide management practices at the certified operation.

Perseus has designed the processing facilities to be compliant with the Code where possible and will endeavour to adopt all elements of the Code when in operation.

3 PROJECT DESCRIPTION

3.1 Project History

The Project is located in a brownfield open pit gold mining area which has historically and recently been operated. The history of the Project is provided in Table 3-1.

Angovia Mining undertook gold exploitation activities, including trenching, core drilling and some open pit activities from the 1980s up to 1991. During 1993 the Compagnie Minières d'Afrique (CMA) was awarded an exploration licence over the larger Yaoure project area. CMA changed the name of the operation to the CMA Mine and subsequently undertook heap leach gold mining operations from 1999 until the mine closed during 2003. This involved open pit mining through stripping and stockpiling of overburden and waste rock and the processing of ore through a cyanide heap leach process.

Perseus Yaoure SARL (Perseus) acquired the CMA Project in 2004.The purchase was made, under Perseus's previous name, Cluff Gold plc (Cluff) which was formed in 2003 (the company subsequently changed its name to Perseus Mining plc in October 2012). The company name then changed from Perseus to Perseus Yaoure SARL.The purchase agreement included the transferring of the exploration licence. Between 2008 and January 2011, Cluff produced 54 382 ounces of gold from mining at the existing Pits and the processing of gold through heap leach using cyanide at the Cluff Mine. Mining and gold processing ceased in 2011 and since then activities have been focussed on exploration drilling. The current status of the project is that infill drilling is being undertaken to update the resource estimate with the aim of re-commencing mining through the expansion of the former Angovia, CMA and Cluff Project as the Yaoure Project.

Table 3-1 Project history

Designation	Decrees	Number and Type of Permit	Owner
Attribution	Decret 2002-376 du 31 Juillet 2002	PR-168: Research Permit	CMA : Compagnie Miniere d'Afrique
Transfer	Arrête 048/MEMME/DM du 08 Octobre 2004	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Renewal	Arrête 045/MEMME/DM du 29 Aout 2005	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Renewal	Arrête 035/MME/DM du 12 Novembre 2007	PR-168: Research Permit	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2008-258 du 18 Septembre 2008	PE-33: Mining License	Cluff Gold West Africa (WA) Cote d'Ivoire
Authorization to work on ML 33	Letter 045/MMPE/CAB/ du 13 Mai 2013	PE-33: Mining License	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2013-840 du 11 Decembre 2013	PR 397: Research Permit in replacement of ML 33	Cluff Gold West Africa (WA) Cote d'Ivoire
Attribution	Decret 2015-665 du 30 Septembre 2015	PR-615: Research Permit	Perseus Mining Cote d'Ivoire SARL

The current exploration licence expires in August 2015. The General Direction of Mines and Geology, who is responsible for issuing mining authorisations through the Ministry of Industry and Mines, instructed Perseus to submit a feasibility study as part of the exploration licence renewal and mining licence application. This ESIA is part of the Feasibility Study that will support the mining licence application. Note, however, that due to time constraints, the ESIA is partly based on data provided by Perseus in April 2015.

3.2 Geological Setting

The regional geology of the Project area (SRK, 2008) is comprised of a series of Archaean, Birimian, greenstone belts separated by older migmatites and granites. The Angovia deposit itself occurs within one of the Birimian greenstone belts and is hosted by the Yaoure Unit, which is comprised of a mafic and metavolcanic series, felsic instusives and minor conglomerates in association with calk-alkaline and ultramafic intrusives, all of which strike in a north-north-east orientation.

The geology of the Yaoure deposit area is relatively simple. The majority of the Project area is underlain by mafic volcanics, which are predominantly massive and in the form of pillowed basalts. The north part of the area is intruded by massive granodiorite that locally has a subtle porphyritic texture. Elsewhere, but mainly associated with the main Yaoure Zone, there are numerous porphyry sills. A volcaniclastic unit, mainly of epiclastic origin, is situated near the contact of the granodiorite to the north. The granodiorite intrusive to the north is not mineralised while the one in the Yaoure pit contains quartz veins which are well mineralised.

The mineralisation at Yaoure is contained within two shallow dipping (<30 Degrees) gold bearing north-south trending packages controlled by a thick zone of brittle-ductile shearing. The Yaoure Central package is a 200 metre thick, lower grade mineralised zone with higher grade lenses and cross-cutting high grade sub-vertical quartz veins. The CMA package is a more discrete, relatively continuous 20 metre thick zone approximately 140 metres above the Yaoure Central body.

The Yaoure unit forms a syncline of tholeiitic basic metavolcanics and sediments overlain by more acidic volcanic rocks (SRK, 2008). The tholeiitic rocks are thought to have been formed following hydrothermal alteration and are composed of chert, disseminations and veinlets of pyrite, pyrrhotite, chlorite, epidote, tourmaline and carbonates. The overlying acidic to intermediate volcano-sedimentary rocks are thought to represent pyroclastic and acidic pyroclastic flows.

All of the above rocks have been intruded by basic to ultra-basic plutonic rocks and acidic intermediate calc-alkaline volcano-plutonic rocks and the whole package is in turn overlain by the Benou polygenic conglomerate. All of these have been deformed by a series of east west striking shear zones and intruded by associated greyish quartz veining.

Primary and secondary lateritic weathering profiles have also developed throughout the area above the conglomerate. The gold mineralisation itself appears to be primarily located in structurally controlled alteration zones in intermediate volcanic rocks. The geology of the Project is shown in Figure 3-1.

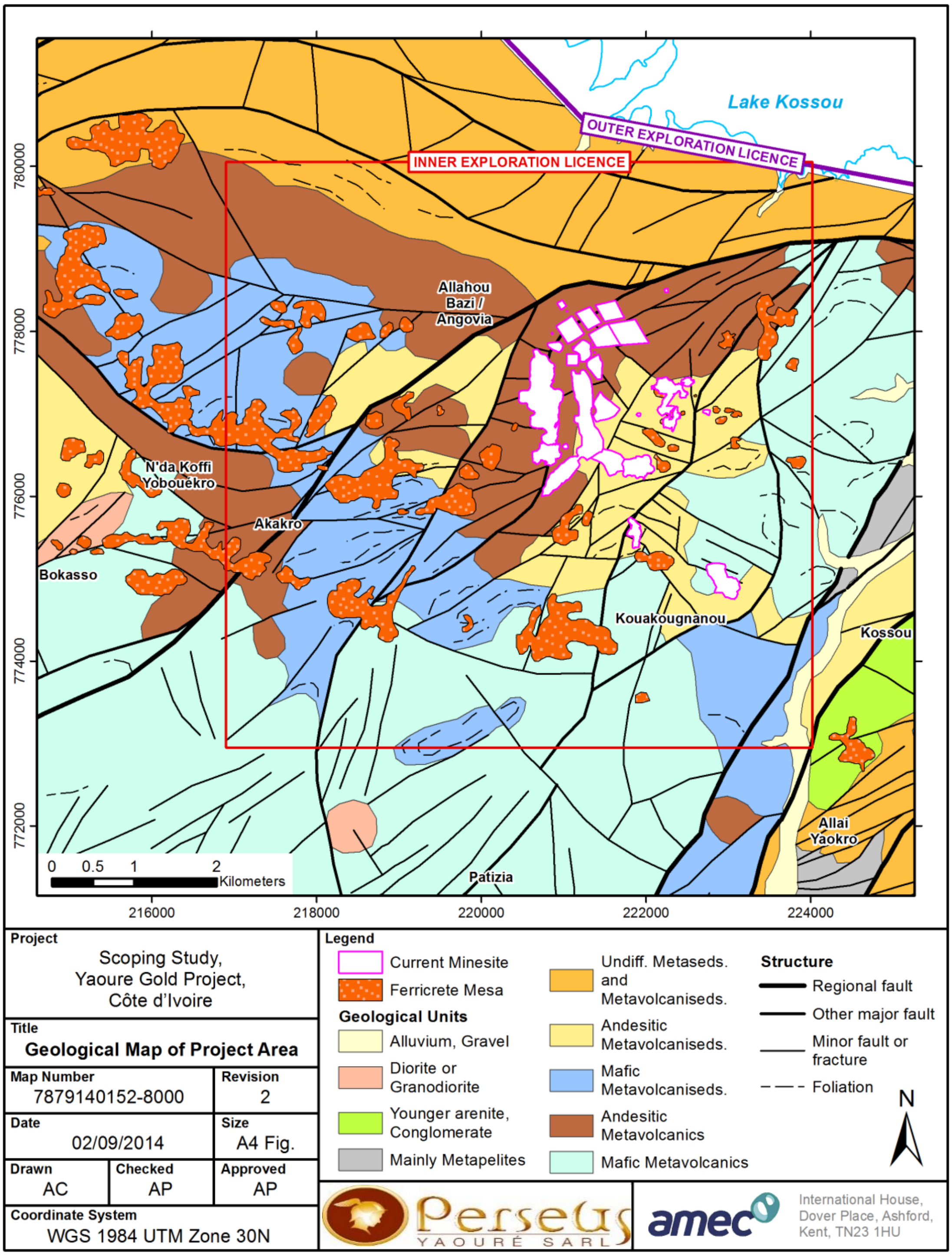


Figure 3-1 Geology of the Yaoure Project (Source: Perseus Mining)

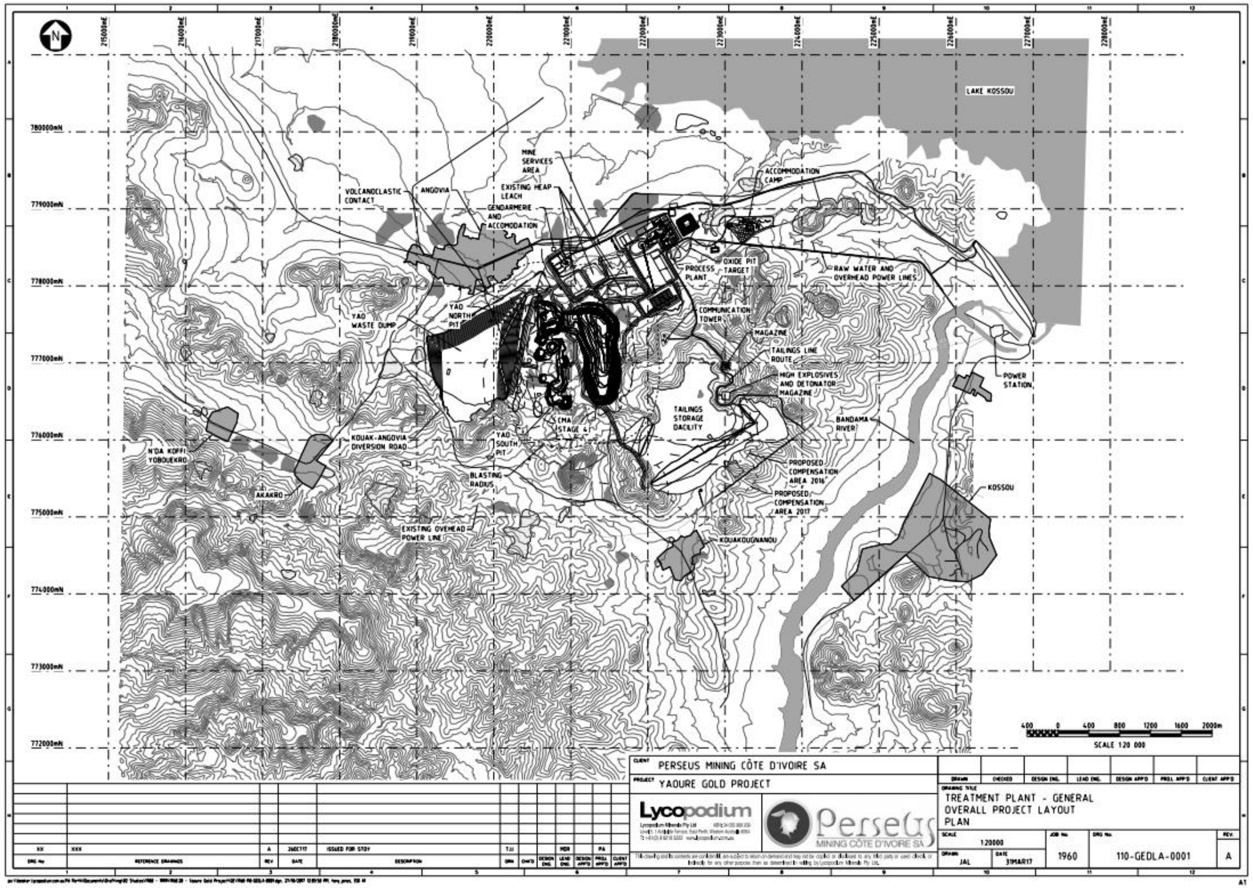
The 2014 Preliminary Economic Assessment (PEA) Report indicates that there is a major NE-trending regional fault passing through the Yaoure Central pit. Movement along this fault line generated two additional NNE-SSW trending faults branching into the Yaoure gold deposits (see Figure 3-1). Some additional geological structures have been identified by Steenkamp in 2012. Structures have the potential to act as pathways for groundwater and could either lead to seepage into the pit or transportation of potential contaminants into groundwater resources. It could also act as containment barriers. The potential linkage of structures to surface water resources will have to be further investigated at a later stage.

3.3 Technical Description of the Yaoure Project

3.3.1 Site Layout

A preliminary layout of the open pit, waste facilities and other mining infrastructure is provided in Figure 3-2 and, with a higher resolution and full legend, in **Error! Reference source not found.**.

Figure 3-2 Preliminary site layout (Higher resolution and larger format see Error! Reference source not found.**)**



3.3.2 Project Infrastructure

From the preliminary layout (see Figure 3-2 and **Error! Reference source not found.**), the following areas have been calculated:

Table 3-2 Footprints of project infrastructure elements (rounded)

Infrastructure element	Area (ha)
Camp	9
Plant & Admin Office Area	43.5
Waste Rock Dump	147
Recycling and Waste Disposal	0.5
TSF Pond	125
TSF Embankment/s	72
Water Storage Dam	9
Pit	50
ROM Pad & Stockpile	27
Haul Roads	25
Other Site Roads	5
Perimeter Fence	5
New Workshop (MSA)	10
Water Line Corridor – Plant to TSF	3.5
Gendarme Accommodation	0.5
HV Powerline Corridor	6.5
Magazine Area	2
Total footprint	**540.5**

* It should be noted that soil stockpile areas will be located in close proximity to extractive waste management facilities (WRD, TSF), and their footprint (assuming 0.2 m stripping depth and 5 m height of stockpiles) will be very small compared with the WRD and TSF footprints of 344 ha. This is within the accuracy of footprints at this Project development stage.

3.3.3 Open Pit, Waste Rock Dumps and ROM Pad

Pit:

The pit size that is being considered in this ESIA is optimised for a gold price of US$ 1200 per ounce. The open pit will be mined at an average rate of 25Mtpa (ore and waste rock), of which ore is mined at an average rate of 4.5 Mtpa. The maximum mining rate will be 30 Mtpa. The mining rate of waste rock will drop off towards the end of the mine life (estimated 6 years). Over the operational life of the mine, a total of 162 Mt rock will be mined, of which 137 Mt are waste rock and 25 Mt are ore. The strip ratio, i.e., the ratio of waste rock to ore, is 5.4:1 The average ore grade (gold content of the ore) is 1.8 g/t.

The last year of mining operation will be year 6), and after that only stockpiled ore will be processed.

The maximum depth of the open pits will be 200 m below surface level.

Blasting will take place no more than once per day, at the same time of the day (approximately 4 pm during shift change).

The blasting radius around the open pit operations is 500 m.

Waste Rock Dumps:

The total amount of 137 Mt of waste rock will be deposited on a waste rock dump/s (WRD).

The waste rock dump will consist of waste rock that will be profiled and vegetated, preferably from the outside first, to isolate the village from the noise and dust generated at the open pit and during the discharge of sterile rocks.

The residues will need to be managed in order to be stored safely and the environment protected. The tailings pond will cover an area of approximately 197 ha.

The tailings dam will be designed as a downstream dam, which is considered to be the safest type of dam.

The tailings pond containment base will be compacted and will include perforated drainage pipes, so that water from the interstices can be collected and treated. This will reduce the risk of groundwater contamination.

ROM pad:

The ROM pad will be located on top of the spent heap leach pads and will have a volume of approximately 2.7 million m^3.

3.3.4 Mine Fleet and Major Equipment

At the present stage of Project development, the following information on the major vehicles and mining equipment is available however it is subject to change:

Table 3-3 Major mining equipment (preliminary)

Number Required	Equipment	Description	Make	Model
1	Service Truck			
7	Lighting Plant		Allight	
1	Personnel Carrier			
1	Light Vehicle (In-Pit)			
4	Pumps			
1	Explosives Truck			
4	Primary Shovel	22 m^3 electric hydraulic face shovel	CAT	6040E
2	Primary Loader	10-12 m^3 Front end loader	CAT	992
1	Secondary Drill	89-127 mm drill	Sandvik	DP1500i
11	Primary Drill	152-229 mm drill	Sandvik	D45KS
4	Primary Track Dozer	610 hp 19 m^3 track dozer	Komatsu	D375A-6R
1	Primary Wheel Dozer	485 hp 8m^3 wheel dozer	Komatsu	WD600-6
1	Backhoe	3.5-4.5m^3 backhoe	Komatsu	PC850SE-8R
3	Water Truck	HD785 Chassis with 75 m^3 tank	Komatsu	HD785
1	Fuel Truck	Lubrication truck	Komatsu	
1	Tire Handler	Tire handler mounted on WA500-6R	Komatsu	TH4500
34	Primary Truck	130-150 t Truck	Caterpillar	785C
3	Primary Grader	300hp 5 m Grader	Caterpillar	16M
2	Compactor	213cm Drum Width Compactor 147 hp		

The equipment is subject to review (e.g., refining the ancillary fleet and adding a few road vehicles for the infrastructure). However, for the purpose of the ESIA, the information provided above covers the main emitters of noise and air emissions.

The noise and air emission model, only the largest noise and exhaust emitters were taken into account at this stage. These include the following:

- 34 CAT-785C Primary Trucks;
- CAT-6040E Primary Shovels;
- 2 CAT 992 Primary Loaders; and
- 7 Allight Lighting Plants (located in pit and on WRD as required).

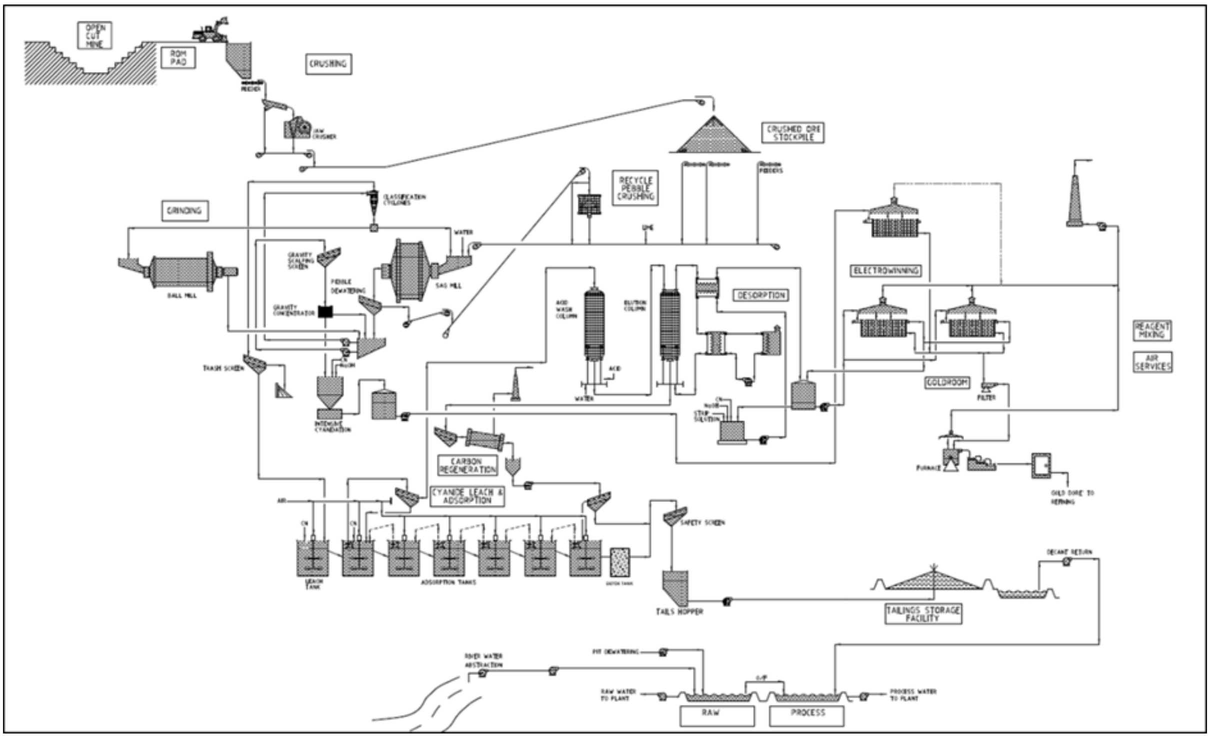
The shovels are equipped with electric drives, so that there are no air emissions and less noise compared to diesel drives. For noise modelling, the loading and tipping will be the most important sources of noise from the shovel operations.

For noise and air quality impact modelling, it is conservatively assumed all of the primary trucks will be running, although in reality some will be out for maintenance. On average each truck will make 2 to 3 trips between the shovel and the ROM/WRD per hour.

3.3.5 Mineral Processing and Process Plant

Oxidized and sulphurized materials will be crushed and ground and then leached to the treatment plant using a standard cyanide leaching process. Absorption, an elution / regeneration phase, electrolytic extraction and melting will follow. The final product is the gold bar. A simplified process flow sheet is shown in **Error! Not a valid bookmark self-reference.**.

Figure 3-3 Simplified flow sheet of the Yaoure process plant



Reagents and consumables that will be used in the process include the following:

- Mill balls;
- Sodium cyanide;
- Lime;
- Caustic soda;
- Copper sulphate;
- Sodium metabisulphate; and

- Flocculants.

The plant will be designed according to the standards of the Cyanide Code (International Cyanide Management Institute, ICMI).

The specific consumption of these reagents and consumables will be defined at a later stage. Cyanide briquettes will be stored on site with a buffer of 3 months, other reagents with a buffer of 1 to 3 months depending on the country of origin.

It is important to note that the process plant is open to the atmosphere so that ventilation (required under the cyanide code for process plant buildings) is not needed.

3.3.6 Roads

Access roads during construction:

Throughout the construction phase of the Project, heavy goods vehicles will have to use public roads. To ensure the safety and health of surrounding communities, measures will be put in place to regulate traffic.

A specific plan for traffic management has been developed to ensure that road traffic risks are minimized to maintain the health and safety of surrounding communities.

Traffic Lanes:

Traffic lanes should be more than 25 m wide, but this will depend on the gear of the mine fleet.

All roads will be compacted and leveled and at this stage of the Project no additional pavement such as asphalt or gravel is planned.

Existing access roads:

The existing access roads will be used to access to the Project.

Public Roads:

The road from Kouakougnanou to Angovia will be diverted around the Project site. The new road will be gentler, shorter and avoid the current elevated ridge, making it safer and easier to use for the local population.

3.3.7 Soil Stripping and Stockpiling

Prior to placing waste rock, building the TSF or infrastructure, soil will generally be stripped, according to the Soil Management Plan (see **Error! Reference source not found.**).

The soil stripping depth is mainly determined by the requirements of soil for closure and rehabilitation. Based on the observation of rapid re-vegetation of thin soil layers by (non-agricultural) specialist plants it seems justified to assume placement of a soil layer of 0.2 m during rehabilitation, which requires a pre-construction stripping depth of approximately 0.2 m if all stripped and stockpiled soil can be fully used for rehabilitation without deterioration.

Nevertheless, land degradation in terms of water retention, nutrients, and texture can not be predicted accurately at this stage of the Project, as more land may be needed to achieve sustainable vegetation cover. The exact amounts of the rehabilitation will be determined on the basis of the tests (field coverage tests) towards the end of the life of the mine. If a thicker land cover is needed, it will be available in sufficient quantities. Therefore, in addition to the minimum depth of 0.2 m, Perseus will make as much topsoil stock as possible technically and economically.

There will be no stripping at the pit because it has already been disturbed by previous operations on the site. Due to the previous existence of heap leach areas, no topsoil will be removed from the ore stockpile area at the treatment plant.

Approximately 102,000 m³ of stored topsoil is still in various locations on the site, after previous operations of the site [2]. These land stocks will be transferred to one of the new storage areas if they interfere with the Project's development activities.

Assuming a floor area of 463.5 ha (see Section 3.3.2 and the assumptions above) and a stripping depth of at least 0.5 m on average, a total of 2.442 million m³ of land (including the existing 102,000 m³ of land stock from the old operations in Angovia) will be stockpiled and available for gradual rehabilitation and later during the closure phase.

Soil will not be stored higher than a few meters to prevent deterioration of its fertile properties and structure. If a stockpile height of 5 m is assumed for the soil stockpiles, an area of approximately 25 ha will be required, which is approximatively 4% of the total project footprint.

Soil storage areas will be located in non-sensitive areas close to disturbed areas and waste facilities and will be protected against vehicle movements and erosion so that the soil is readily available for later closure and rehabilitation works, ensuring low costs through long transport distances and reduced risk of soil deterioration. Further details on soil management measures of Perseus are contained in Section 8.3.

3.3.8 Water Management

The water will come from the dewatering of the pit and the TSF recycling process, which involves water from the rains at the Project site, particularly tailings area. As a last resort, if more water was needed, it would be pumped from Bandama River.

Since aquifer is relatively close to the ground surface, infiltration of groundwater into the pit is certain. Dewatering of the pit may be necessary to ensure permanent and safe work.

The Project aims at minimising the discharge of impacted water. If water must be discharged, it will comply with the requirements of the requirements of Côte d'Ivoire (CIAPOL Arreté No. 01164/04.11.2008), see Section 2.3.4, and where national

[2] Yaoure Gold Project Closure Plan, AMEC, February 2012 and information received from Perseus

standards do not provide limits or guidance, with international standards and recommendations such as the IFC EHS Guidance for the Mining Industry (2007).

For water treatment installations, standard industry proven techniques will be used, including settling ponds for surface runoff to achieve TSS quality requirements, and lime precipitation for heavy metals, should this be required.

With respect to cyanide, any water discharged from the Project will be compliant with the legal requirements of Côte d'Ivoire (see

Table 2-1). Further guidance such as the Cyanide Code (ICMI) will be considered at a later stage and Perseus will endeavour to adopt the Code. Without detoxification of tailings, water delivered to the TSF will have cyanide concentrations of around 50 mg/l (CN_{free}) and 300 mg/l (CN_{tot}). Standard industry proven detoxification processes such as Inco/SO_2/Air are available that can reduce cyanide concentrations to 50 mg/l (CN_{WAD}) or below, however further testwork is required to establish the precise technological and economic parameters. Any water that is discharged will be returned from the TSF to the process plant area where the detox plant is located and treated prior to discharge.

3.3.9 Energy Requirements

The Yaoure Project will require electric power for the plant, shovels and most of the infrastructure, and diesel for the mining equipment (trucks).

Electric power requirements will be approximately 40 MW. It will be sourced from the power station at Kossou barrage that is connected to the national power grid of Côte d'Ivoire. Overhead power lines from the Kossou power station to the Yaroure site will be aligned in the existing corridors of overhead lines/pylons. However, some of the pylons need to be rerouted around the TSF. Additional transformers will be installed at the Kossou station.

Based on information received from Perseus it has been confirmed by the Compagnie Ivorienne d'Electricité (CIE) that taking 40 MW from the existing supply system will affect supplies to any other communities.

Diesel consumption is estimated to be approximately 1,750 m^3 per month, which results in 90 fuel trucks (20 m^3) per month. Fuel storage will be sufficient for 1 week. There is a large fuel storage facility in Yamousoukro which is relatively close to the Yaoure site and allows quick fuel delivery to the Project.

A backup diesel generator of 1 MW will be installed to prevent solids settling in tanks etc.

3.3.10 Construction Materials

Construction materials that will be required for the Project include the following:

- Cement;
- Aggregate, sand, gravel;
- Rock fill, crushed rock;
- Wood (small quantities).

Apart from cement that will be delivered from Yamassoukro, construction materials will be sourced locally, most likely within the footprint of the TSF. Therefore, no borrow pits will remain after the construction phase that would have to be rehabilitated. All plant, material and supplies that cannot be locally sourced will be imported through the port of Abidjan or San Pedro.

3.3.11 Logistics, Supplies and Traffic

Main access to the site is via the good standard dual carriage surfaced A1, which directly links Abidjan to Yamoussoukro. The single carriage surfaced A6 provides access from Yamoussoukro to the Bandama river crossing at Lake Kossou. This stretch of the road consists of 16 km of paved road connecting the Kossou hydroelectric power station to the main Bouaflé–Yamoussoukro road at Toumbokro. Yamoussoukro lies a further 24 km to the south-east. Although the condition of the road is relatively good, it does deteriorate closer to the Bandama crossing. The gravel road to the western end of the Bandama river running through Kouakougnanou up to the Project will be realigned and upgraded (graded, smoothed).

Fuel deliveries will require approximately 90 trucks per month. As a preliminary estimate, this figure can be doubled to account for other deliveries, i.e., 180 trucks per month or 9 trucks a day, assuming deliveries to take place 5 days a week.

Delivery frequencies may vary over the various phases of the mine's life cycle and may peak during the construction period. However, for the purpose of this ESIA, the same order of magnitude of vehicle movements is assumed for the construction and operation phase.

Workers and employees will be mainly commuting between Angovia including the surrounding villages and the mine/process plant. Approximately 600 people are estimated to commute in and out every shift, using private means of transport or walking. No bus shuttles are planned at this stage.

3.3.12 Sewage

Sewage collection and treatment facilities (including permanent sewage treatment and mobile "portaloos") will be provided for workers and employees at the pit, plant area, camp and admin area. Sewage management will be designed for a maximum of 500 people on site at any one time.

Before discharge into the environment, sewage will be treated using modular/containerised standard technology to the discharge standards of the IFC General EHS Guideline (2007), see Table 3-4

Table 3-4 Discharge quality of treated sewage

Pollutants	Units	IFC EHS Guideline
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total Nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
TSS	mg/l	50
Total coliforms	mg/l	400

3.3.13 Non-Extractive Wastes

As a general policy, all reasonable efforts will be made to minimise or eliminate the waste streams, and/or to re-use and recycle waste material, wherever feasible. Non-extractive wastes, i.e., wastes not directly resulting from mining or processing, include the following:

- Packaging waste;
- Aluminium cans;
- Paper, cardboard;
- Scrap metal;
- Wooden packaging waste, crates, pallets;
- Glass;
- Plastics;
- Aerosol containers;
- Empty drums, containers;
- Used oils and oil filters;
- Oily rags;
- Used tyres;
- Wet acid batteries (car batteries) and other batteries;
- Used vehicles;
- Waste electrical and electronic equipment (WEEE);
- Fluorescent tubes;
- Medical waste;
- Wood (crates, boxes);
- Food waste;
- Contaminated soil; and
- Sewage and sewage treatment sludge (see Section 3.3.12).

Medical waste will be incinerated on site in a special incineration facility.

Other waste streams will be further segregated, as necessary, to ensure that incompatible materials are not stored together. Waste storage carts, bins, or barrels will be arranged in such a way as to provide adequate access for container transfer and emergency response. Waste intended for off-site disposal will be collected at a specific transfer station.

Perseus will work with suppliers to take back any wastes whose origin can be identified, and with local waste management organisations to work out suitable waste management strategies for other wastes.

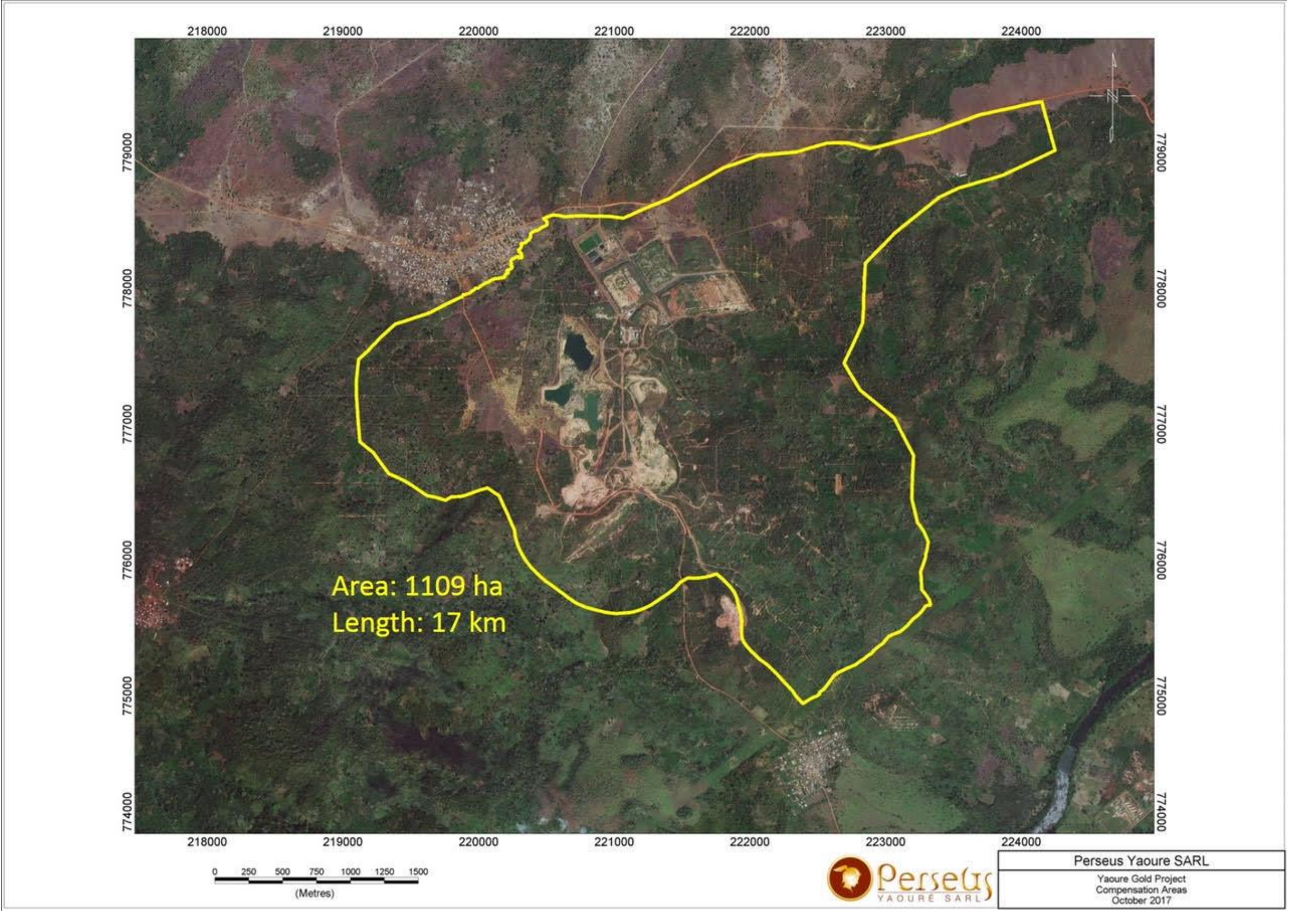
Should hazardous wastes arise that cannot be returned to suppliers, appropriate waste management solutions will be determined by Perseus in conjunction with the relevant authorities, which may include a dedicated waste management facility on site. This is in line with international best practice, e.g., IFC EHS Guidelines for Mining, (2007), which recommends management of hazardous wastes "in hazardous waste management facilities specifically designed and operated for this purpose". Such landfill would be closed at the end of the mine life.

3.4 Land acquisition

During the pre-construction and construction phases Perseus will have to acquire 1,109 ha for the Project. It is estimated that roughly 15% of the land in the study area is agricultural land. Impacts will occur before the construction machinery is mobilised and will endure for the life of the Project. It is anticipated that no physical displacement will take place as a result of impacts upon residential land or structures. Similarly, it is expected that no significant temporary or permanent limitations/restrictions of land use will occur outside the project footprint.

Artisanal mining sites located within the Project footprint will also be affected by economic displacement impacts. However, it must be noted that artisanal mining activities in the Project area have recently significantly reduced as a result of Government action to curb illegal mining activities.

Figure 3-4 Project Land Requirement



3.5 Employment Opportunities of the Project

During construction and operation, the Project will provide employment for up to 2000 people. During operation, it is currently assumed that approximately 250 people will find permanent employment at the Project. However, contractors and temporary jobs will add to this number and increase the overall employment opportunities that come with the Project.

The skill needs will be matched with the skills available in the Project area, so that recruitment and employment will be maximized in the Project area, as the Project strives to comply with the IFC Performance Standards (IFC CP, 2012), PS 2, on labor and working conditions.

The required skills are shown in Table 3-55. They will be matched against the availability of skills in the Project area (see Socio-Economic Baseline Study, **Error! Reference source not found.** and Section 6.12.), so that local recruiting and employment from the Project area is maximised.

Table 3-5 Skills required during operation

Mine Operations	
Mine Manager	1
Mine Operations Supervisor	4
Production Engineer	4
Trainer	4
Administrative Assistant (Mine Ops)	4
Shovel Operators	12
FEL Operators	8
Truck Operators	122
Track Dozer Operators	16
Grader Operators	12
Backhoe Operators	4
Other Equipment Operators	12
Dispatch Operators	4
Blast Crew	4
Dewatering Crew	8
Mine Ops Coverage	12
Mine Maintenance	
Maintenance Manager	1
Maintenance Supervisor	4
Maintenance Planner	4
Administrative Assistant (Maint)	4
Maintenance Crew	32
Mine Maintenance Coverage	4
Technical Services	
Chief Mine Engineer	1
Planning Engineer	1
Senior Surveyor	1
Mine Surveyor	2
Senior Mine Geologist	1
Mine Geologist	2
Grade Control Technicians	2
Samplers	4
Administrative Assistant (Tech Services)	1
Plant General	
Process Manager	1

Plant Superintendent	1
Trainer / Day crew co-ordinator	1
Clerks	3
Senior Metallurgist	1
Plant Metallurgist	1
Project Metallurgist	1
Junior Metallurgist	1
Samplers	3
Shift Chemist	1
Laboratory Assistant	3
Driver / General Hnad	1
Plant Operation	
Crushing & Milling	
Shift Supervisor	4
Crusher Operators	4
MillOperators	4
Assistants	4
Labourers	4
Leach & CIP	
Shift Supervisor	4
Operators	4
Assistants	4
Labourers	4
Elution & Gold Room	
Shift Supervisor	4
Operators	4
Assistants	4
Labourers	4
Reagents & Services	
Shift Supervisor	4
Operators	4
Assistants	4
Labourers	4
Plant Maintenance	
Maintenance Superintendent	1
Maintenance Planner	1
Maintenance Trainer	1
Electrical Supervisor	1
Technician, Electrical, Instrument	3
Condition Monitoring Technician	1
Mechanical Supervisor	1
Maintenance Fitters	2
Boilermakers / rubber liners	2
Riggers	2
Trade Assistants	6
day crew	6
GA Labour	
General Manager	1
Secretary	1
Operations Manager	1
Commercial Manager	1
Senior Accountant	1
Accountant	2
Clerks	5
Stores Manager	1
Procurement Officer	2
Warehouse Clerks	5
HR Manager	1

Training Officer	1
IR Officer	1
Clerks	3
Safety Manager	1
Safety Officers	5
Safety Trainer	2
Clerks	1
Environment Manager	1
Environment officers	3
Clerks	2
Site & Vehicle Maintenance Manager	1
Maintenance Planner	1
Junior mechanical engineer / Maintenance Clerk	8
Vehicle Mechanics (including Lubrication)	5
Mechanical / Electrical engineers	8
Mechanical / Electrical assistants	12
Warehouse Clerks	4
Community Relations Manager	1
Community Relations Officers	3
Clerks	1
Security Manager	1
Senior Security Officers	3
Security Officers	2
Clerks	2
Contracted Out Services	
Security	50
Medical - doctor	2
Medical - Nurse	8
Cleaning	25
Catering	25
Total Personnel on Site	**611**

A recruitment plan will be implemented by Perseus. A specific local development plan has been developed as part of this ESIA.

3.6 Site Security

Perseus will contract a reputable security service provider to ensure general site security and access control. The guards will not carry firearms. The gender distribution of the guards will reflect the gender distribution of the mine work force. Separate security arrangements will be contracted for the transport of doré and money needed to pay employees.

3.7 Project Closure and Rehabilitation

Closure and rehabilitation are described in the Conceptual Closure Plan (see **Error! Reference source not found.**). The following paragraphs summarise the overall approach to closure and rehabilitation.

During the meeting held with ANDE in July 2014, it was advised that the previous closure plan for Angovia mine be incorporated into the new closure plan.

As a guiding principle, Perseus is committed to sustainable closure and rehabilitation of the Project at the end of its life. Progressive rehabilitation will keep the environmental liabilities to the technically and economically possible minimum at any time during the operation phase.

All mine infrastructure (plant, camp etc.) will be removed, as required in Art. 145 of the Act No, 2014-138, 24 March 2014 on the Mining Code, and the affected areas graded and revegetated. Possible exceptions that would have to be discussed with the local communities and the competent authorities include buildings that can be used by the community or the government.

As noted above, the Project is an extension of an existing former mine operation. It will integrate some existing infrastructure from the old mine (for example, heap leaching facilities and other related facilities) and others will be replaced by new mining infrastructure and waste rock storage area, which will be rehabilitated at the end of the Yaoure Project or treat the heap leach material so that it no longer exists.

Roads will be rehabilitated or kept open for the community to continue using if the Government makes the request.

In the pit, the rising groundwater will form a lake. According to the results of geochemical tests carried out on waste rock, the leaching of metals and the formation of Mining Acid Drainage (DAM) should not be a problem. Therefore, the management of pit lake waters is not planned after closure phase.

Steep benches of the open pit will be smoothed out, and safety berms will be erected along the pit perimeter to prevent access and minimise safety risks.

Waste rock piles will be geotechnically stabilized throughout the life of the mine. They will also be reshaped and leveled if necessary to merge with the surrounding environment. They will be re-vegetated to minimize erosion while ensuring that the slope angle is similar to the surrounding environment and that the piles blend well into the landscape and there is no visual impact. Existing drainage channels will be maintained. Additional channels will be built if necessary for the fight against erosion.

The current closure scheme for the TSF provides tailings deposits at the edge of deposit area by following a specific deposit method whereby the basin will be progressively filled in the last years of mine operation. Then the overall will be covered with a 0.2 meter layer of topsoil for revegetation.

The water storage ponds and settling ponds will be filled and the surface will be leveled and revegetated, unless the administrative authorities and local communities request that the ponds remain in place for their own use.

Environmental monitoring will continue during the closure and rehabilitation phase and the post-closure phase to meet compliance with legal requirements and identify areas where corrective action is required (including erosion processes and water management).

Social and socio-economic consequences of mine closure inevitably include redundancy and loss of livelihoods. However, during the operation period, Perseus Yaoure will strive to develop the socio-economic capabilities of the Angovia community and the wider area so that negative consequences of mine closure are mitigated as far as possible. This may include, but not be limited to, skills development programmes for Perseus employees to improve their post-Project employability, or local purchasing programmes of Perseus to help local businesses develop sustainably and develop business outside the Project. Details of the socio-economic mitigation strategy will be developed closer towards the end of the mine life.

A conceptual plan for closure and rehabilitation has been developed and describes in detail the closure and the environmental rehabilitation strategy. This plan will be re-specified during the mining operation phase.

3.8 Timeframe of the Project

The expected duration of the various phases of the Project life cycle is summarised in Table 3-6. Note that the duration of each phase is indicative only and is subject to further refinement as Project development progresses.

Table 3-6 Expected duration of Project life cycle phases

Phase	Duration
Construction and commissioning	18 months
Operation	6 years
Closure	3 years*
Post-closure	TBD

*Assuming that a significant portion of the closure work is completed as part of the reclamation operations and that the tailings pond cover can begin soon before the end of the tailing pond disposal.

4 ALTERNATIVES

4.1 Tailings and Waste Rock Dumps

Mine wastes (waste rock) and processing wastes (tailings) are typically the largest infrastructure elements of a mining operation and siting them is therefore the first step in an assessment of project alternatives.

SRK has completed a site assessment for the mine and process waste management options[3]. This is combined with a high level environmental and social appraisal of the options completed by Knight Piésold Limited (KP) in conjunction with Amec Foster Wheeler. The WRD and TSF siting study is based on the options that had been proposed in the Preliminary Economic Assessment (PEA) for the Project in April 2014. The PEA identified four potential TSF locations, designated TSF 1 to TSF 4. All TSF siting options have sufficient storage capacity (at least 70 Mt).

Since then, new siting options have been proposed as part of the Definitive Feasibility Study. Perseus will confirm their preferred options during the FEED Study.

Two potential WRD locations were also identified, then one known as the Angovia dump and the other as the East Dump. As part of the locations assessment, a mine waste workshop was held at the Perseus office in January 2015 attended by representatives of Perseus, Tetra Tech, Amec Foster Wheeler and KP. The criteria addressed included various geographical, environmental, social and cultural issues relating to the entire site and then focusing on the sites identified in the PEA. Details of the TSF and WRD site assessment process can be found in the KP report (see Footnote 3); the results are summarised in the following.

[3] Mine Waste Pre-Feasibility Study - Options Assessment, LO301-00564/01 (10 February 2015)

Figure 4-1 Yaoure Project siting alternatives

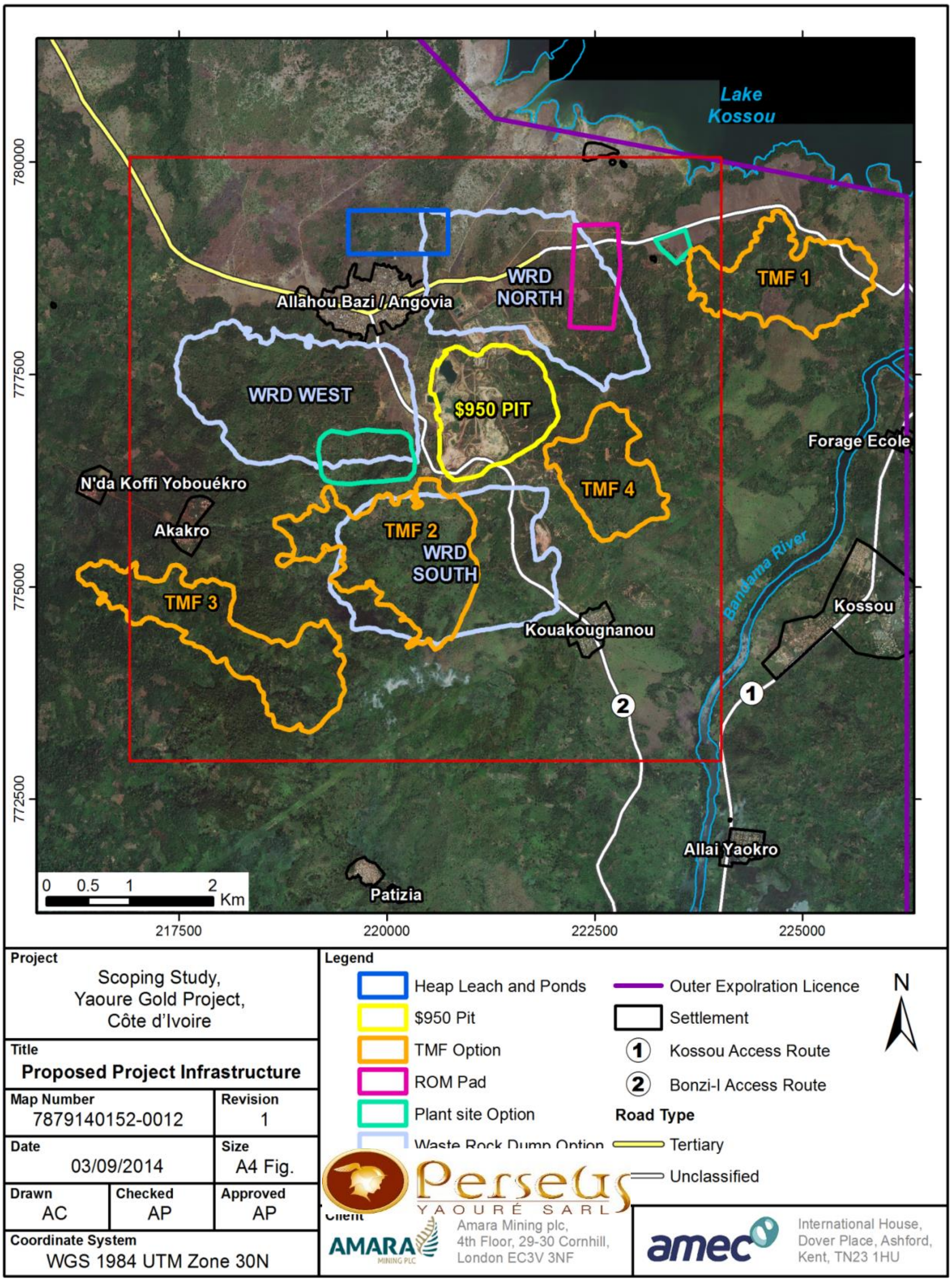


Table 4-1 Assessment of the TSF options

Site Option	Technical aspects	Community aspects	Water	Visibility	Cultural Heritage aspects	Biodiversity	Soil and land use aspects	Total cost
TSF 1	Low dam height Very far from process plant (high pumping costs) Requires the relocation of the current power line Located on a stretch of the current main Kossou access road, that would have to be re-routed	Relatively close proximity to communities Area downstream of the TSF and part of the footprint used for intensive agricultural purposes Small village within footprint would have to be relocated, close proximity of fishing	Significant seepage potential (Lake Kossou) May require liner and extensive monitoring Difficulty to manage runoff due to close proximity to river	High	Two sacred forests affected	Small wetland would be affected	Very little wet based (sensitive) soils present. Workability of soils is more problematic due to higher erosion potential. Land capability is higher in terms of agricultural potential, therefore more sensitive.	Very high
TSF 2	Low dam height Power line must be re-routed Located closer to the actual proposed mine and on partially disturbed land, including the old CMA WRD	Close proximity, plantations within footprint Artisanal miners use the area, this would stop their activities within the TSF footprint and buffer zone	No issues Monitoring of drinking water wells in Kouakougnanou to confirm hydrogeological model results predicting no impacts	Medium-high	Ceramic relics Two sacred forest affected Cemetery/graves	Some smaller wetland areas within the footprint	Significant areas of wet based soils present – workability of soil is moderate. Moderate to low land capability therefore less sensitive.	Lowest
TSF 3	High dam height Very far from process plant (high pumping costs)	Farming in the area, intensive rice farming, also cacao and coffee Access to the site may impact on Akakro village	No issues	Low	Metallurgy relics (slags), ceramics, polishing tools Sacred forest affected	Probably no issues	Limited but significant areas of wet based soils. Soil workability is moderate. Moderate arable land capability	Medium
TSF 4	High dam height Would sit over a large part of potential resource ("Eastern Thrust")	Very close proximity to community Plantations within footprint, coffee and cacao farming Artisanal mining within footprint	Multiple points for seepage	Medium-high	Sacred forest affected 2 cemeteries within footprint	Probably no issues	Limited areas of sensitive soils. Workability of soil is moderate. Moderate to low arable land capability	Very high

Apart from slurry deposition options, deposition of filtered tailings and co-disposal of tailings and waste rock were considered. However, slurry deposition is the preferred option at this stage so that only options involving slurry are considered further. Deposition methods may be revisited at a later stage, this may change the preferred deposition method which could significantly reduce the footprint and other environmental issues.

Following the selection of the TSF site, potential WRD sites were evaluated. The WRD site options were also evaluated in the KP report mentioned above. As a general rule, waste rock dumps are located very close to the open pit. Therefore, the site selection process focused on options that are sufficiently close to the open pit and would cover already disturbed areas:

- WRD A, similar to "WRD West" in

- Figure 4-1;
- "Large WRD A", combining two waste rock dumps (A and B) into a single one, extending WRD to the west and south;
- "WRD South", largely coinciding with the TSF 2 site;
- WRD B, similar to "WRD North" in

- Figure 4-1; and
- WRD C, similar to TSF 4 in

- Figure 4-1 (see also assessment of TSF 4 in Table 4-1).

The main results of the evaluation process are briefly summarised below:

Table 4-2 Waste Rock Dump site options

Site Option	Advantages	Disadvantages
WRD A	Covers partly disturbed area Closer to pit, thereby reducing the overall mine footprint Can be used as noise and dust barrier between the village of Angovia and the open pit Can be extended into barrier (safety berm) using waste rock for construction	High visibility, close proximity to Angovia village May cause noise and air quality impacts in initial stage of construction (but will then function as noise/dust barrier, see left column) Large group of artisanal miners within the footprint The access road from Angovia to Akakro and the access road from Kouakou to Angovia will have to be relocated, will therefore impact on access
"Large WRD A"	Same as WRD A	This option would have made the road re-alignment more difficult, more forest would have been disturbed, and visibility would be much higher (height of other WRD options is limited to 360 masl, which is in line with surrounding landscape elevation). This option would also be more expensive.
WRD South	Same assessment as for TSF 2 (see Table 4-1), but site already chosen for tailings disposal	
WRD B	Located largely on a brownfield site Will cover large parts of former heap leach operations, can take advantage of compacted ground as natural liner for seepage water collection.	May affect some archaeological remains and graves/cemeteries, sacred forest Restricted to the north, would otherwise affect road from Kossou to Angovia Relatively close proximity to Angovia, may be a noise/dust issue in eastern outskirts of Angovia
WRD C	Will add extra space for waste rock deposition if required	If footprint extends too far north, it would sit over a large part of potential resource ("Eastern Thrust") Longest haul distance (farthest from open pit) Very close proximity to community, plantations are within footprint, Medium-high visibility Sacred forest (can be moved), 2 cemeteries within footprint

4.2 Plant Site

For the plant site, brownfield areas were considered during the PEA, as shown in

Figure 4-1. A third option was identified during the PFS, see Figure 3-2. The final selection as shown in the preliminary Project layout (Figure 3-2 and **Error! Reference source not found.**) was made based on economic and accessibility considerations (proximity to the open pit, ROM pad etc.).

4.3 Ore Processing Alternatives

Two gold recovery process flow sheets were considered as part of the PEA and are briefly summarised in Table 4-3.

Table 4-3 Process Alternative Assessment

Process Option	Preliminary Assessment
Heap leach plus tank leaching	• Lower energy consumption (for heap leach component) • Managing heap leach pads in tropical climates with high rainfall is challenging • Impoundment dams would also have to be considerably larger than if in a less wet climate in order to prevent possible contamination of the surrounding area • Lower gold recovery • Larger footprint • Higher closure costs
Tank leaching (CIP)	• Higher energy consumption • Higher gold recovery • Smaller footprint • Lower closure costs

The preferred alternative at this stage is tank leaching and electorwinning of oxide and sulphide ores (no heap leach). This will require a smaller overall footprint area and the cost for closure should be lower.

Non-cyanide options (e.g., thiosulphate, thiourea) were also considered but are not economically practicable for the ore mineralogy at Yaoure. Challenges include reagent cost and the efficiency of gold recovery. In summary, while alternatives to cyanide have been developed there is currently no viable alternative which is commercially available.

As part of the Feasibility Study, further detailed optimisation has taken place, to reduce power consumption and improve Project economics.

4.4 Energy Source Alternatives

Perseus conducted a Power Supply Study to assess the cost of various alternatives of off-take from Lake Kossou hydropower station. Perseus is in advanced negotiations with CIE (Compagnie Ivorienne Electricité), the hydropower supplier at Lake Kossou, to supply 40 MW to the Project. The increased demand can be supplied through additional high-voltage power lines within the existing servitude. Additional transformers will be required at the Kossou station, but this is not considered a technical or environmental problem.

The alternative is to use diesel generators for power supply. This will lead to increased emissions of exhaust gases and consequently air quality and noise issues. Diesel generators will also contribute to an increase in greenhouse gas emissions.

An energy options study has been completed that looked at electric versus diesel power for the in-pit shovels. Results show that electrical shovels are more economical and will therefore be assumed in this ESIA.

4.5 'Zero' Option

An ESIA in line with international best practice should include assessment of the "zero" option, i.e., a consideration of the Project not proceeding. Should the proposed Project not go ahead as proposed, the zero option would result in no land take and disturbance from industrial-scale mining. The zero option would also result in foregoing the positive impacts arising from tax and social contributions, royalties, inward investment, creation of employment opportunity and the spin-offs of workforce training and improvements in national, regional and local infrastructure that attend such Project development. Improvements of the infrastructure that will provide benefits both to the local population and the economy in the region would also not be realised.

In the absence of the mining Project as proposed by Perseus, biodiversity will not be impacted by mining activities. However, in this case, other Project alternatives such as uncontrolled artisanal mining would become more likely, as income opportunities from the mining Project would not occur. These alternatives would mean a higher likelihood of unsustainable development, compared to a mining Project designed to contribute to establishment of improved and sustainable livelihoods for local communities as intended by Perseus in compliance with international best practice, such as the IFC Performance Standards.

5 STAKEHOLDER ENGAGEMENT IN THE ESIA PROCESS

The purpose of stakeholder engagement is to ensure informed consultation and participation has taken place and that the views, interests, and concerns of stakeholders are taken into account in the assessment of the Project. Stakeholder participation should directly inform Project decision-making, particularly regarding the design of impact avoidance and mitigation measures. Stakeholder engagement through the impact assessment process aims to improve the relationship between the proponent and neighbouring communities, build broad community support for the Project and avoid any surprises during the formal community consultations of the ESIA process.

A separate Stakeholder Engagement Plan has been developed that will be periodicaly updated (**Error! Reference source not found.**).

Stakeholder engagement is a continuous process throughout the different phases of the ESIA, as illustrated in Figure 5-1. The Stakeholder engagement process of the

Scoping Phase and the ESIA Phase is documented in **Error! Reference source not found.** and **Error! Reference source not found.**.

Figure 5-1 Stakeholder Engagement Process

Phase	Activity
SCREENING	Identification of needs in terms of regulatory analysis, pre-feasibility studies and impact evaluation
SCOPING	High-level definition of project impacts and stakeholders, definition of ESIA terms of reference
BASELINE AND FIELD SURVEYS	Identification of socio-environmental baseline conditions and detailed mapping of project stakeholders
IMPACT EVALUATION	Evaluation of socio-environmental project impacts
MITIGATION & ENHANCEMENT	Definition of mitigation and enhancement measures in the framework of socio-environmental management plans
MONITORING	Identification of monitoring plans to measure and redress performance indicators
REVISION & DISCLOSURE	Preparation and presentation of a detailed report to local authorities and communities

Stakeholder Engagement

5.1 Scoping Phase

A stakeholder engagement process was commenced as part of the scoping phase and includes the following:

- Identification of stakeholders: A database has been compiled to include all stakeholders identified during the scoping phase, including communities and authorities. The existing Perseus stakeholder database was used as basis.
- Project Introduction: Project introduction was made through the distribution of letters, site notices and background information documents (BID) and consultation meetings. This contained information regarding the project, the ESIA process, the public consultation process and contact details of the applicable consultants.
- Meetings:

- Meetings were held with all the relevant national (Abidjan) and regional authorities (Bouaflé, Daloa and Yamoussoukro) who will be involved in the ESIA process or who may have direct interest in the Project. The purpose was to introduce the Project to authorities and to gain an understanding of all requirements which have to be considered as part of the ESIA process;

- Meetings with community representatives, which included youth and woman's group representatives were held on 9 July 2014 (during which the Project was introduced) and 12 July 2014 (to allow the communities to provide feedback); and

- Incidental community liaison in surrounding communities to introduce the Project and obtain feedback on potential concerns.

5.2 Main ESIA Phase

The main ESIA Phase includes all steps from the definition of the baseline study field programme, to the identification of mitigation and enhancement measures and management plans as part of the assessment of the various expected impacts. The main ESIA Phase took place from January till July 2015.

5.2.1 Stakeholder Mapping

Project stakeholders were assessed and categorised according to their function, type of partnerships and in the following categories:

- National Administration Stakeholders – includes relevant ministries and political/governmental authorities located in Abidjan;

- Advisory and Technical Public Agency – includes relevant advisory and technical bodies that support governmental authorities;

- Regional Administration Stakeholders (in the regions of Marahoué and Bélier) – includes decentralised institutions like the prefecture, organisations like the elected regional councils, and the regional delegations of the central ministries;

- Sub-Regional Administration Stakeholders (in the sub-prefectures of Bouaflé and Kossou) – includes sub-prefectures, municipalities and rural agglomerations;

- Local Administration – includes village-level authorities (chiefs and committees);

- Local Community – refers to individuals or groups in the communities of the study area;

- Research Institutions – includes universities and research centers;
- NGOs/CSOs – includes formal and informal third sector representatives in the study area;
- Economic Operators/Businesses – includes formal and informal business organisations in the study area; and
- International Organisations – includes UN agencies and other relevant international institutions.

5.2.2 Governance

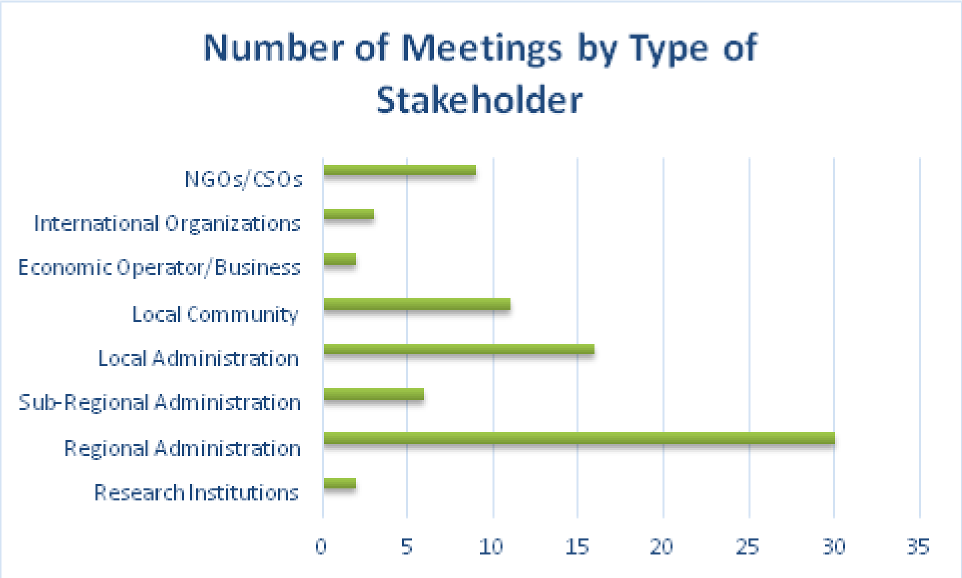
To organise stakeholder engagement activities in a coherent framework, two governance bodies were used as main point of reference. These were:

1. The Community Consultation Committee (CCC) – Composed of mainly community representatives, the CCC holds regular bi-weekly meetings with Perseus management pursuing the following objectives:
   a. Reporting concerns, questions, requests from the community to Perseus;
   b. Ensuring all members of the community have access to project-information and opportunities; and
   c. Discussing the status of community relations issues with Perseus.
2. ESIA Committee – Composed of local authorities, community representatives, ESIA consultants and Perseus, the ESIA Committee has the following tasks:
   a. Supervise and facilitate the ESIA works;
   b. Validate socio-environmental findings; and
   c. Express recommendations on mitigation measures and management plans.

5.2.3 Meetings

During the main ESIA phase, more than 40 meetings took place with different types of stakeholders. Figure 5-2 illustrates the number of times that each group of stakeholders was engaged during the main ESIA phase. An exhaustive list of meetings detailing date, participants and interactions is provided in **Error! Reference source not found.**.

Figure 5-2 Number of Meetings by Type of Stakeholder (Source: rePlan 2015)



5.3 Future Stakeholder Engagement

The ESIA report will be submitted to the Environmental Agency for approval. According to national regulations, Perseus will ensure the participation of ESIA experts to the day(s) of the "enquête publique". All interested parties will receive a presentation of the ESIA findings (most notably the Non-Technical Summary, Section 0 of this Report) and will be able to make written and oral contributions to the improvement of the report.

In addition, Perseus will consult with the ESIA Committee to organise the field restitution and disclosure session. ESIA experts will present the findings of the ESIA report to the local authorities and communities to ensure the highest possible dissemination of project information.

5.4 Grievance Mechanism

The IFC Performance Standards require a Grievance Mechanism. A Grievance Management System receives and addresses concerns raised by stakeholders in a transparent, constructive, timely, confidential (if desired), culturally appropriate and accessible manner. This system will likely comprise the following four basic mechanisms:

The First Order Mechanism should comprise an informal resolution process, in which a stakeholder brings forward his/her concern for discussion with his/her representatives at the LRC or with members of the Technical Team, such as the Grievance Management Officer. Perseus expects that the vast majority of questions and concerns will be heard and resolved within these informal interactions.

If however this informal process does not resolve the issue satisfactorily, complainants should be encouraged to make use of any of the other mechanisms presented below.

The Second Order Mechanism should comprise the formal management of substantive, difficult and/or written comments and concerns by the Grievance Management Officer. This mechanism should consist of a formal Registration, Reporting, Validation, Investigation and Resolution process. Again, Perseus anticipates that most substantive grievances will be successfully resolved by this mechanism.

If however the Grievance Management Officer, working in collaboration with other Technical Team members cannot resolve the matter, or when more complex issues require higher-level decision making, grievances should be forwarded on to the Third Order Mechanism.

The Third Order Mechanism should involve the presentation of grievances to a multi-stakeholder forum, namely the LRC, for discussion and resolution. Perseus hopes that such forums will serve as an important and trusted arbiter in complicated grievances. Deliberation and any decision taken by the LRC should be reflected in the minutes, and a written response provided to the complainant thereafter.

The Fourth Order Mechanism involves the formal judicial system. Perseus recognises that it is unlikely to be able to satisfactorily address all grievances with the amicable mechanisms outlined above, and that all parties have the right under national law to take their grievances into the judicial system at any time. Perseus will inform those who prefer litigation of their rights, entitlements and the existence of any legal aid.

Perseus will appoint a Grievance Management Officer who will assume overall responsibility for administration of the Grievance Management System. Depending on the scope of displacement and the volume of grievances anticipated, the Grievance Management Officer may be a full-time or part-time resource.

6 ENVIRONMENTAL AND SOCIAL BSELINE

6.1 Climate and Meteorology

The following is a summary of the detailed baseline data provided in **Error! Reference source not found.**.

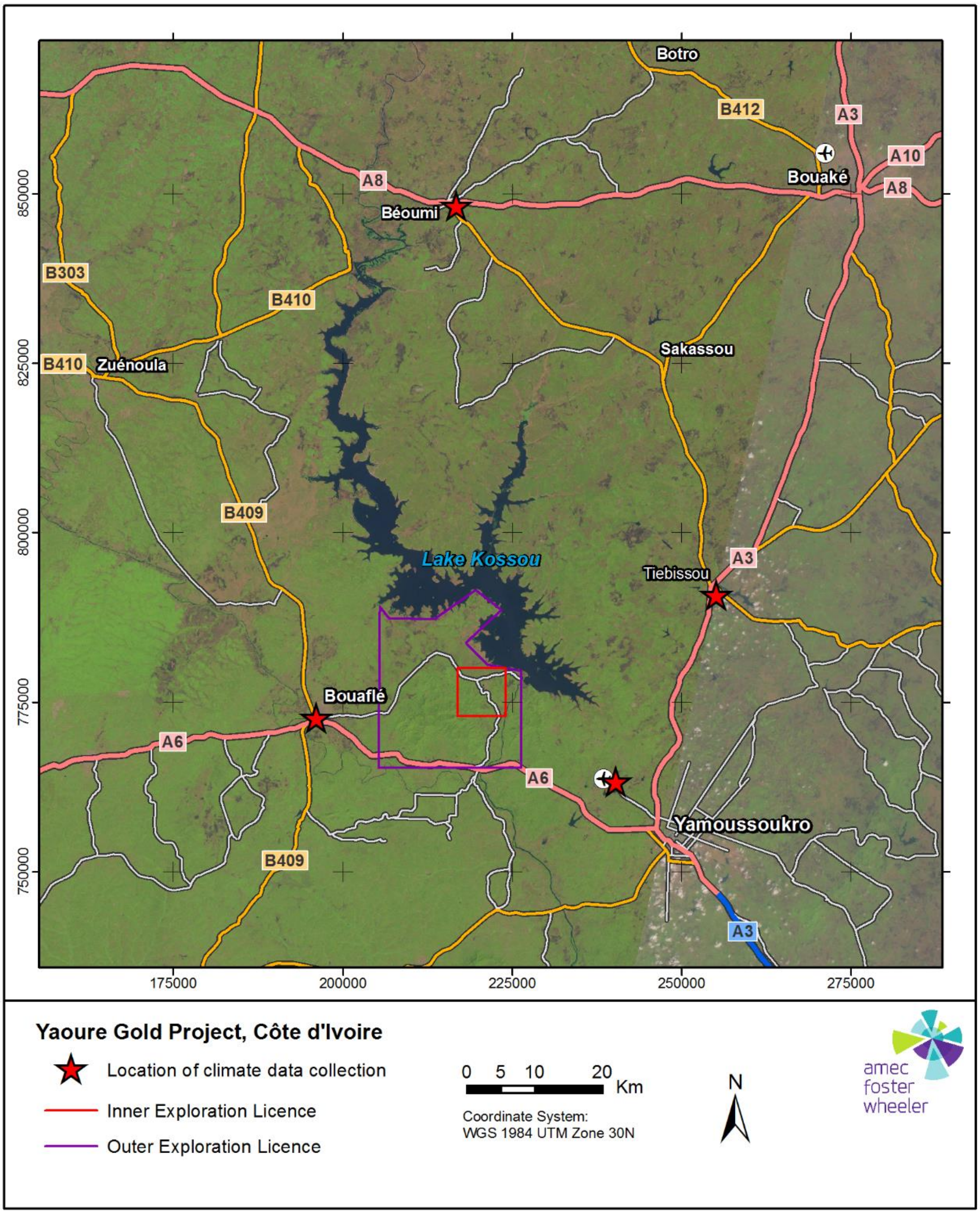
6.1.1 Input Data

Long term weather records are available from each of the four weather stations near to the Yaoure site. Basic information related to the datasets and weather stations is provided in Table 6-1 below. The location of each of the weather stations relative to the site is shown on Figure 6-1.

Table 6-1 Input Data

Location and record length	Approximate coordinates	Altitude (masl)	Comments
Béoumi 1939-1997	Lat: 07°40 Long: 05°34	223	Excluded: 1939, 1993
Bouaflé 1924-1997	Lat: 06°59 Long: 05°45	187	Excluded: 1993
Tiébissou 1953-1996	Lat: 07°09 Long: 05°13	190	Multiple years missing data. Data set not considered further.
Yamoussoukro 1975-1997	Lat: 06°54 Long: 05°21	196	Excludes 1988-1992

Figure 6-1 Climate Dataset Locations



6.1.2 Rainfall Analyses

6.1.2.1 Scope

This section presents the methods and results from a number of rainfall analyses that include:

- Summary of monthly observed rainfall data (mean, standard deviation, maximum, minimum, wet days) from the vicinity of the Yaoure site;
- Determination of the most applicable data for use in Extreme Value Analysis (EVA);
- EVA to determine 24 hour rainfall depths for a variety of return periods, including the Probable Maximum Precipitation (PMP) event; and
- Intensity Duration Frequency (IDF) analysis.

6.1.3 Monthly rainfall analyses

The results are presented in Table 6-2. All of the mean annual rainfall depths are comparable, and there is good correlation between all of the monthly mean rainfall depths, the strongest correlation being between Yamoussoukro and Bouaflé (1975-1997) at 0.95. Despite this, differences in the distribution of monthly averages are observed. Notably, wetter Aprils are observed at Bouaflé (mean of 141 mm (1975-1997) and 144 mm (1924-1997)) compared to Yamoussoukro at 108 mm. Yet mean rainfall in July – the wettest month in the region – is greater at Yamoussoukro (183 mm) than Bouaflé (143 mm) for the 1975-1997 period, albeit the difference is much less for the Bouaflé (1924-1997) data which has a mean of 177 mm in July. Moreover, the maximum monthly rainfall in July is significantly higher at Bouaflé (410 mm for both datasets) than at Yamoussoukro (281 mm).

The mean annual number of wet days (deemed to be days with rainfall >0.4mm) is also significantly higher at Yamoussoukro (100 days) than at Bouaflé (74 days, 1975-1997 and 86 days,1924-1997) and at Béoumi – 70 days, 1975-1997 and 69 days, 1940-1997).

Table 6-2 Summary of Monthly Rainfall Data from Yamoussoukro Airport, Bouaflé and Béoumi

Station & Dates	Stat	J	F	M	A	M	J	J	A	S	O	N	D	ANN	ADM
Yamoussoukro (1975-1997)	Mean (mm)	14	47	92	108	167	183	110	90	152	118	39	15	1135	75
	SD (mm)	26	28	53	56	88	64	84	74	74	61	30	18	203	20
	Max (mm)	95	101	182	249	390	281	282	258	260	262	125	54	1439	118
	Min (mm)	0	0	0	0	0	89	6	7	5	41	3	0	676	42
	Mean wet days	1	4	8	8	12	14	10	11	14	12	5	2	100	NA
Bouaflé (1975-1997)	Mean (mm)	10	48	104	141	151	143	96	113	154	99	38	13	1123	91
	SD (mm)	14	42	48	57	73	55	68	87	82	46	41	23	229	42
	Max (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930	223
	Min (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818	47
	Mean wet days	1	3	6	8	9	10	7	7	10	8	3	1	74	NA
Bouaflé (1924-1997)	Mean (mm)	16	61	117	144	160	177	91	104	202	129	47	26	1280	87
	SD (mm)	25	46	55	56	70	78	69	67	92	66	42	31	259	31
	Max (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930	223
	Min (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818	47
	Mean wet days	1	3	7	8	10	11	7	8	13	10	4	2	86	NA
Béoumi (1975-1997)	Mean (mm)	5	36	79	112	128	108	121	141	184	99	25	9	1047	94
	SD (mm)	11	34	35	44	63	54	85	91	78	43	21	11	203	31
	Max (mm)	65	157	340	294	291	294	307	322	450	242	131	103	1607	175
	Min (mm)	0	0	0	48	18	45	0	18	48	16	0	0	529	49
	Mean wet days	1	3	5	7	8	8	7	9	11	8	3	1	70	NA
Béoumi (1940-1997)	Mean (mm)	8	47	93	121	126	129	104	125	209	115	41	18	1136	92
	SD (mm)	15	39	58	53	58	63	76	78	80	55	33	24	228	28
	Max (mm)	65	157	340	294	291	294	307	322	450	242	131	103	1607	175
	Min (mm)	0	0	0	48	18	45	0	18	48	16	0	0	529	49
	Mean wet days	1	3	5	7	7	8	6	9	11	8	3	1	69	NA

ANN = Annual rainfall, ADM = Annual Daily Maxima.

Mean Wet days determined on the basis of days with gauged rainfall in excess of 0.4mm.

Notes: Minimum: 1974-1976, mean: 1962-1964, maximum: 1938-1940.

6.1.4 Extreme value analysis

6.1.4.1 Method

The Bouaflé daily data were taken forward to the extreme value analysis (EVA). The whole period from 1924 to 1997 was used, with the exception of 1993 which was omitted because the record was incomplete in that year. In total, 72 observed years were included in the analysis, which is considered more than sufficient for this approach.

Both Gumbel (EV1) and Generalised Extreme Value (GEV) distributions were fitted to the annual daily maxima data from Bouaflé. All of the data points fell within the +/- 5 percentile confidence limit with the exception of the third highest value (~+7 %). The EV1 distribution was considered the more appropriate at this stage due to the inability to verify the veracity of the GEV parameters at this location in the absence of sub-daily rainfall for Bouaflé.

The EVA results are shown in Table 6-3. It is noted that the 1:10,000 and 1: 1,000,000 year return period events were not produced within the analysis framework but were extrapolated by fitting a curve through the data that were generated during the analysis.

Table 6-3 Extreme Value Analysis (EVA) results for Bouaflé

Return Period (years)	24 Hr Rain Depth (mm)
1.01	36
1.1	52
2	82
5	109
10	127
15	137
20	144
25	149
50	166
80	177
100	183
200	199
500	221
1,000	238
10,000	293
1,000,000	414

6.1.5 Synthesis of intensity duration frequency (Idf) curves

6.1.5.1 Methodology

The formula of Sherman (1931) was used to generate the IDF curves. For a given return period, rainfall intensity (I, mm/h) is related to duration (T, hours) by means of three empirically determined constants (a, b and n):

$$I = \frac{a}{(b+T)^n}$$

If the rainfall depth for any given duration is compared with the daily total rainfall, the constant 'a' can be eliminated and a rainfall ratio determined instead which uses only two constants (b and n) as follows:

$$RR_T = \frac{I_T \times T}{I_{24} \times 24} = \frac{T}{24}\left(\frac{b+24}{b+T}\right)^n$$

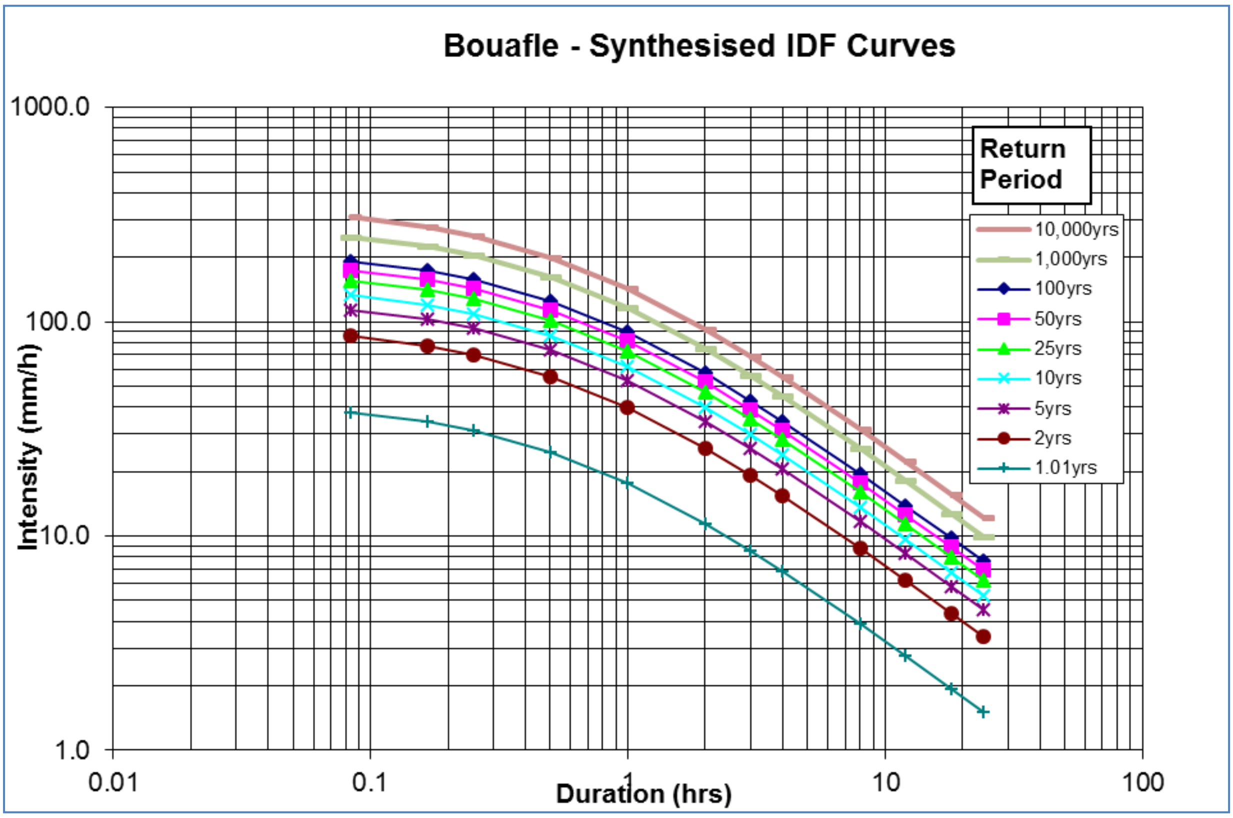
Values of b and n vary between locations, but studies have found values to be similar within a region. Values are published in the literature but are often hard to find. It is better if the values can be back analysed from data for the location, or a similar location nearby. For comparison, published values for 14 stations in Ghana are b = 0.60 and n = 0.86 to 1.03. Values of b=0.6 and n=0.9 have been used at this stage subject to further analyses on assessment of the additional rainfall data from Kossou dam.

The resultant table of IDF data and corresponding curves are shown below in Table 6-4 and Figure 6-2.

Table 6-4 IDF results (rainfall intensity in mm/hr)

Return Period	**Duration (mins)**								
	5	**10**	**20**	**30**	**60**	**120**	**180**	**720**	**1440**
1	37.9	34.2	31.2	24.7	17.6	11.4	8.5	2.8	1.5
2	85.4	77.0	70.2	55.7	39.7	25.7	19.2	6.2	3.4
5	113.9	102.6	93.5	74.2	52.9	34.2	25.5	8.3	4.5
10	132.7	119.6	109.0	86.4	61.7	39.8	29.7	9.6	5.3
20	156.4	141.0	128.5	101.9	72.7	47.0	35.1	11.4	6.2
50	174.0	156.9	143.0	113.4	80.9	52.3	39.0	12.6	6.9
100	191.5	172.7	157.4	124.8	89.1	57.5	42.9	13.9	7.6
1,000	249.4	224.8	204.9	162.5	116.0	74.9	55.9	18.1	9.9
10,000	307.1	276.9	252.3	200.1	142.8	92.2	68.8	22.3	12.2

Figure 6-2 Synthesised rainfall IDF curves for Bouaflé



6.1.6 Probable Maximum Precipitation

6.1.6.1 Introduction

Probable Maximum Precipitation (PMP) is conceptually defined as the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year (WMO, 1986). From the practical perspective of this project, there is a requirement to estimate the PMP for the catchments in which critical mine infrastructure is located, for example, for calculating the probable maximum flood (PMF) through the TSF for sizing spillway structures using rainfall-runoff modelling approaches.

A variety of techniques exist for the estimation of PMP as summarised in the WMO Manual for Estimation of Probable Maximum Precipitation (WMO, 1986). Most of these techniques were developed for large drainage basins in mid-latitude regions and require synthesis of a range of meteorological data such as dew point and wind speed at a range of altitudes to arrive at PMP estimates. Procedures are presented which can be used to adapt these techniques to tropical regions. However, the WMO manual notes that regions with limited data such as Côte d'Ivoire present particular difficulties in applying these techniques. Nevertheless, an alternative statistically based method for smaller areas (<1,200 km^2) is also presented, which is based on recorded annual precipitation maxima alone. It is this approach that has been adopted for estimation of PMP for this study, based on the Bouaflé data described above.

6.1.6.2 Methodology

The point PMP for a given storm duration is estimated as a function of the mean and standard deviation of the annual rainfall maxima series as follows:

$$X_m = \overline{X}_n + K_m S_n$$

where X_m is the PMP; $\dot{X}_n$ and S_n are the mean and standard deviation (with the maximum value removed) of a series of n annual maxima, and K_m is a scaling factor. A study of 24-hour rainfall from 2,700 climate stations, of which 90% were in the USA, was used in the estimation of K_m. This was found to vary inversely with mean annual maximum daily rainfall. The technique also involves application of correction factors to adjust the mean and standard deviations for the effects of possible outliers and sample size, and adjustment of the final point PMP value to reflect the effect of a fixed observational time interval. Finally, an areal reduction factor is required to convert to point PMP for a particular catchment area, should this be required. Values of K_m and the various other factors required are estimated from a number of graphs presented in Chapter 4 of WMO (1986).

6.1.6.3 Results

The approach described above was applied to the Bouaflé annual daily maxima series with incomplete years removed. The following values were estimated:

$\overline{X}_n$ = 84.63 mm (n =71)

S_n = 26.14 mm (n =71)

K_m = 12 (based on the 2 year 1 hour rainfall derived from IDF table)

PMP = 450 mm

Given that the record length exceeded 50 years, no adjustments were required to the mean and standard deviation for record length, and the long record length also meant that a significant impact from outliers could be discounted. An adjustment factor for a fixed observation interval of 1.13 was applied. This yielded a value for the daily PMP for Yaoure of 450 mm. It is noted that, based on the mean annual daily maxima from Bouaflé, K_m takes a value of 16 which would have resulted in a corresponding PMP of 568 mm – this is considered overly conservative however.

As identified above, the final value of PMP using the technique applied here is sensitive to the estimation of a single parameter K_m. Given the different climatic conditions under which this relationship was derived (the relationship between $\dot{X}_n$ and K_m was largely derived on data from the USA), its use in a tropical climate must be treated with some caution. By way of comparison, extrapolation of the EV1 best-fit curve for data presented in Section 3.1 to return periods of 10,000 and 1,000,000 years yields respective daily rainfall totals of 293 mm and 414 mm. This would suggest that the value of 450 mm obtained above may be an overestimate of the actual point PMP for Yaoure but is nonetheless in the order of the 1:1,000,000 value.

6.1.6.4 Operational Use of PMP Estimate

The value derived above is a point value for daily rainfall at Yaoure. For practical application, the following issues need to be addressed:

- Values need to be derived for a range of storm durations. It is by no means clear that the meteorological circumstances that would lead to the generation of a PMP event would conform to the IDF relationship derived in Section 4.3. However, in the absence of any other information, it is suggested that the relationship developed above is used for current purposes;

- Point values should be adjusted by an areal reduction factor to account for the catchment area they are being applied to. However, given that the catchments of interest in this study are small, it is suggested that application of the areal reduction factor can be neglected. This would yield a conservative estimate of the resulting PMF.

6.1.7 Other climate data

Table 6-5 to Table 6-9 summarise average monthly data for temperature, evaporation, humidity, wind speed and sunshine hours. Other climate data for Yamoussoukro are included in the SGS EIS (2007).

Table 6-5 Yamoussoukro Temperatures, 1975-1997 (SGS, 2007)

MONTH	Maximum Temperature (°C)			Minimum Temperature (°C)		
	Mean minimum	Mean maximum	Mean	Mean minimum	Mean maximum	Mean
JAN	32.36	34.8	33.56	10.6	20.7	17.53
FEB	32.92	36.9	35.02	14.7	22.1	20.23
MAR	31.2	37.0	34.26	16.5	23.62	21.51
APR	31.7	35.13	33.56	16.2	23.55	21.54
MAY	31.3	33.6	32.27	15.3	22.95	21.27
JUN	29.11	32.2	30.56	14.3	22.41	20.96
JUL	21.6	30.3	28.73	13.0	29.07	20.69
AUG	27.74	30.9	29.22	17.1	21.76	20.51
SEP	29.0	32.8	30.25	18.5	21.9	20.90
OCT	29.74	33.3	31.02	18.4	22.01	20.80
NOV	30.43	33.8	31.79	16.2	21.45	19.79
DEC	30.76	33.4	31.92	12.4	20.46	17.78

Table 6-6 Yamoussoukro Average Evaporation, 1994-2001 (SGS, 2007)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
Evap (mm)	104.2	117.8	108.3	80.2	63.7	48.3	48.1	46.3	47.6	50.3	54.7	59.7	829.0

Notes: Measured with a Piche Evaporimeter – glass 'U' tube filled with water and closed at one end.

Table 6-7 Yamoussoukro Average Relative Humidity, 1977-1997 (SGS, 2007)

MONTH	Maximum Humidity (%)			Minimum Humidity (%)		
	Minimum	Maximum	Mean	Min	Max	Mean
JAN	87.6	99.4	95.8	16.5	49.2	31.8
FEB	90.0	98.5	94.8	23.4	42.3	33.4
MAR	88.7	98.8	95.6	27.6	50.1	41.8
APR	92.8	99.2	96.9	42.3	56.5	49.1
MAY	95.3	99.6	97.9	49.7	61.5	55.6
JUN	95.6	99.7	98.1	54.9	64.4	60.3
JUL	94.9	99.6	97.6	50.3	68.0	62.7
AUG	91.8	99.4	97.1	53.4	69.1	62.0
SEP	95.5	99.3	97.8	47.4	66.8	58.8
OCT	95.5	99.7	98.3	45.9	62.5	56.2
NOV	96.6	99.7	98.7	41.2	60.8	52.0
DEC	96.1	99.5	98.3	25.3	51.9	40.8

Table 6-8 Yamoussoukro Average Wind Speed, 1994-2001 (SGS, 2007)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
Speed (m/s)	1.00	1.60	1.80	1.90	1.60	1.70	1.80	2.00	1.80	1.10	2.30	1.10	1.60
Direction	NSW	SW	SSW	SSW	SSW	SSW	SW	SW	SW	SW	SSW	W	
Type	H - M	M			M	M	M	M	M			H	

H – Harmattan, M – Monsoon

Table 6-9 Yamoussoukro Average Sunshine Hours, 1981-1997 (SGS, 2007)

MONTH	Mean	Min	Max
JAN	198.3	126.4	245.8
FEB	197.1	144.6	245.8
MAR	204.0	156.5	251.8
APR	208.4	174.5	237.5
MAY	210.5	157.7	241.4
JUN	151.5	121.7	182.3
JUL	111.6	72.1	154.9
AUG	97.9	40.0	135.5
SEP	116.5	88.1	38.1
OCT	171.0	126.8	201.0
NOV	179.2	153.2	216.7
DEC	166.4	91.2	217.6

Temperature has been monitored at the Yaoure site since 2009.

Mean monthly temperature for the period 2009-2013 is shown in Table 6-10.

Table 6-10 Yaoure Monthly Temperature 2009-2013 (Perseus data)

	Mean monthly temperature (ºC)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2009	39.8	29.4	28.5	28.4	27.7	27.3	25.3	25.3	26.2	26.8	26.9	27.8
2010	28.5	29.3	29.8	29.5	28.8	27.1	25.8	25.7	26.6	27.3	28.0	27.3
2011	26.6	29.0	29.1		28.0	27.0	25.4	25.8	26.9	27.3	27.9	26.5
2012	27.4	28.8	29.8	28.5	22.2	26.5	25.3	25.0	26.5	26.9	22.2	26.9
2013	26.7	29.7	29.0	29.0	27.7	26.8	25.5	25.1	26.1	27.1	27.5	26.8

6.1.8 Trends related to climate change

Current climate change prognoses for the project area are available from the World Bank Climate Portal (World Bank 2015). Temperature is rising, and overall rainfall is falling although there may be an increasing trend in the intensity of extreme events. Over the forecast periods of 2020-2039 and 2040-2059 these trends are set to continue on the basis of ensemble assessment of a range of climate models. Trends and changes are illustrated in **Error! Reference source not found.**.

At 2060 temperature is expected to have risen by between 0.96 and 2.26 degrees. Rainfall is expected to remain stable for low emission increase scenarios, but may decrease slightly in the mid and late 21st century under the highest emission scenario. In general therefore, within the expected life of mine for this project, overall climatic conditions are not expected to change significantly.

6.1.9 Summary

Climatic parameters for use in the ESIA are summarised in Table 6-11 below.

Table 6-11 Summary of climatic parameters

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Minimum rainfall[1] (mm)	0	0	18	26	22	40	1	3	16	9	0	0	818
Mean rainfall[1] (mm)	16	61	117	144	160	177	91	104	202	129	47	26	1280
Maximum rainfall[1] (mm)	116	203	287	264	347	410	328	302	440	296	194	153	1930
24 hour probable maximum precipitation[2] (mm)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	450
Mean minimum temperature[3] (°C)	17.5	20.2	21.5	21.5	21.3	21.0	20.7	20.5	20.9	20.8	19.8	17.8	N/A
Mean maximum temperature[3] (°C)	33.6	35.0	34.3	33.6	32.3	30.6	28.7	29.2	30.3	31.0	31.8	31.9	N/A
Average evaporation[4] (mm)	104.2	117.8	108.3	80.2	63.7	48.3	48.1	46.3	47.6	50.3	54.7	59.7	829.0
Minimum relative humidity[5] (%)	31.8	33.4	41.8	49.1	55.6	60.3	62.7	62	58.8	56.2	52	40.8	N/A
Maximum relative humidity[5] (%)	95.8	94.8	95.6	96.9	97.9	98.1	97.6	97.1	97.8	98.3	98.7	98.3	N/A
Average wind speed (m/s)	1.00	1.60	1.80	1.90	1.60	1.70	1.80	2.00	1.80	1.10	2.30	1.10	1.60
Average sunshine hours (min) (hours)	126.4	144.6	156.5	174.5	157.7	121.7	72.1	40.0	88.1	126.8	153.2	91.2	N/A
Average sunshine hours (mean) (hours)	198.3	197.1	204.0	208.4	210.5	151.5	111.6	97.9	116.5	171.0	179.2	166.4	N/A
Average sunshine hours (max) (hours)	245.8	245.8	251.8	237.5	241.4	182.3	154.9	135.5	38.1	201.0	216.7	217.6	N/A

Notes
[1] Rainfall data obtained from the Bouaflé 1924-1997 dataset, as presented in Table 6-2. Minimum and maximum values are highest points on the record, not average minima and maxima.
[2] PMP was determined using the Bouaflé annual daily maxima series (with incomplete years removed), as described in Section 6.1.6.
[3] Temperature data obtained from the Yamoussoukro average temperature dataset (1975-1997), as presented in Table 6-5.
[4] Evaporation data obtained from the Yamoussoukro 1994-2001 dataset, as presented in Table 6-6.
[5] Relative humidity data obtained from the Yamoussoukro 1977-1997 dataset, as presented in Table 6-7.
[6] Wind speed data obtained from the Yamoussoukro 1994-2001 dataset, as presented in Table 6-8.
[7] Sunshine hours obtained from the Yamoussoukro 1981-1997 dataset, as presented in Table 6-9.

6.2 Surface Water Baseline

The following is a summary of the detailed baseline data provided in **Error! Reference source not found.**.

6.2.1 Local and regional context

The project site is mainly drained by perennial and non-perennial tributaries of the Bandama River. Many stream courses are ephemeral, only flowing during one of the wet seasons.

Drainage from the major part of the area of the proposed open pits flows northwards into Kossou Lake. The extreme southern edge of the open pit may drain southwards into a separate tributary catchment which flows into the Bandama (Blanc) River south of Kossou Dam (see **Error! Reference source not found.**). Figure 6-3 shows the surface drainage system for the wider area encompassing the project site, and Figure 6-4 shows the project area within the Inner Exploration Licence in more detail, together with the current surface water and groundwater monitoring sites.

Therefore, the whole of the project site, including the TSF and other infrastructure, lie within the same sub-catchment whose waters all flow into either Kossou Lake or the Bandama (Blanc) River south of Kossou Dam, north of Toumbokro. This sub-catchment boundary also encloses the Inner Exploration Licence area and runs south from Kossou Lake to N'da Koffo Yobouékro, southwest to Lotanzia, and then ESE to the Bandama north of Toumbokro.

Surface watercourses are used considerably by local communities for drinking water supplies, irrigation, washing etc., albeit many of the watercourses around the project site are ephemeral and have not been observed to flow during the monitoring programme up to the cut-off date.

6.2.2 Bandama River

There was no existing flow monitoring data for any of the Bandama tributary watercourses prior to the commencement of the baseline study for this current project. There is however daily data (with some gaps) from a gauging station for the Bandama River at Marabadiassa, which is just north of the northern extent of Kossou Lake. This record runs from 1962 to 1997 and therefore brackets the construction of the Kossou Dam and formation of Kossou Lake in 1972, but is independent of the managed discharges from Kossou Lake since that time. The Bandama River is the longest in Côte d'Ivoire at 800 km, flowing almost north-south through the centre of the country to discharge into the Tagba Lagoon and the Gulf of Guinea.

Table 6-12 summarises the daily flow data for the Bandama at Marabadiassa into monthly averages.

Figure 6-3 Topography and Drainage of the Project and Surrounding Area

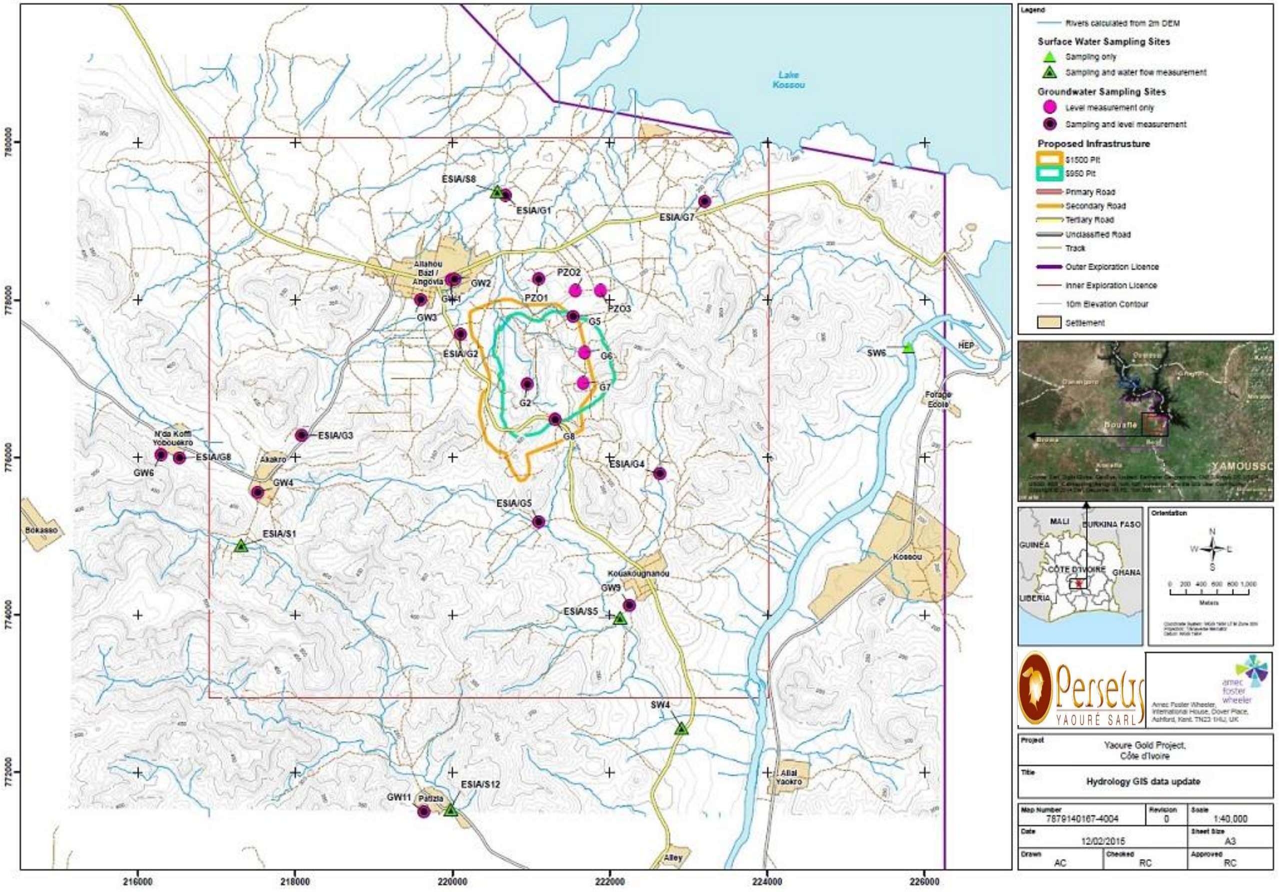


Figure 6-4 Topography and Drainage of the Project Locality and Current Monitoring Locations

Table 6-12 Bandama River Flows at Marabadiassa, 1962-1997 (data provided by Perseus)

	Monthly Mean Stream Flows (m^3/sec)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1962					4.9	8.1	21.5	114.0	538.0	419.0	130.0	49.4
1963	18.5	11.3	9.5	3.9	11.3	35.2	112.0	286.0	617.0	590.0	274.0	60.8
1964	26.7	11.9	5.1	6.0	17.3	37.0	47.0	435.0	1010.0	655.0	175.0	128.0
1965	68.6	35.7	16.7	13.6	11.0	58.8	223.0	443.0	663.0	619.0	154.0	55.1
1966	27.0	13.3	8.4	16.2	16.3	30.4	35.6	231.0	455.0	450.0	163.0	58.5
1967	22.7	15.2	11.8	7.8	14.0	14.5			592.0	425.0	94.4	36.6
1968	15.7	13.0	6.9	7.8	22.4	28.9	122.0	327.0	530.0	464.0	153.0	52.4
1969		29.0	11.1	6.3	3.3	4.0	89.3	222.0	402.0	377.0	335.0	73.1
1970	28.9	14.1	6.9	5.6	6.4	10.0	31.4	375.0	787.0	429.0	80.2	33.0
1971	15.6	7.7	6.7				9.9	185.0	445.0	278.0	48.4	25.9
1972		3.9	1.8	5.0	13.7	86.4	49.0	117.0	140.0	85.9	35.2	10.0
1973	6.6	1.8	0.4	1.8	5.2	3.1	100.0	296.0	333.0	155.0	49.7	10.3
1974	3.0	0.7	0.1	0.5	3.6	4.0	11.7	211.0	442.0	302.0	83.4	12.7
1975	7.8	3.2	1.2	1.0	6.3	7.6	24.4	200.0	526.0	200.0	40.4	16.8
1976	6.7	3.2	2.5	1.9	2.3	6.7	23.0	9.3	6.4	82.0	103.0	16.0
1977	5.8	2.0	0.3									
1978	0.8	0.1	0.0	1.8	8.7							
1979	1.2	0.1	0.0	0.0	4.7	27.9	150.0	344.0	797.0			
1980					10.2	20.5	43.1	181.0	567.0			
1981							56.0	250.0	234.0	120.0		
1982			1.5	9.2	6.9	5.8	17.6	37.6	117.0	55.7	36.0	6.6
1983	1.3	0.6	0.9	1.4	3.3	3.5	6.9	9.7	26.9	16.1	1.6	1.0
1984	0.0	0.0	0.4	0.1	7.2	10.9	23.9	57.4	147.0	83.9	21.7	5.5
1985	2.0	0.3	2.0	7.5	4.9	6.5	52.0	469.0	547.0	139.0	33.7	6.4
1986	3.0	1.7	0.9	3.4	3.3	8.0	11.7	83.7	263.0	115.0	50.4	10.7
1987	3.6	2.7	1.5	1.8	0.8	12.6	14.1	63.9	262.0	143.0	38.5	10.6
1988	3.3	0.7	0.3	0.0		2.9	49.3	172.0	466.0	272.0	29.4	7.8
1989	1.8	0.9	1.4	3.6	3.5	6.4	34.2	284.0	568.0	190.0	56.2	28.1
1990	15.8							139.0	104.0	74.0		
1991	1.4	0.1	0.0	0.0	5.6	14.6	66.8	183.0	359.0	135.0	35.1	7.0
1992	1.7	0.8	0.0	0.2	11.6	20.2	42.0	113.0	162.0	93.1	33.8	8.4
1993	3.4	0.5	0.8	0.3	11.1	15.3	16.4	22.9	125.0	83.3	27.0	5.8
1994	0.7	0.0	0.2	1.5	3.3	12.7	19.6	130.0	267.0	456.0	208.0	20.8
1995	4.9	1.3	0.2	1.0	13.5	7.5	19.5	144.0	327.0	227.0	64.9	14.1
1996	6.3	1.1	0.6	4.8	7.6	16.7	23.6	93.0	427.0	256.0	38.1	12.6
1997	6.7	2.8	0.4	7.2	7.0	26.9	43.8	177.0	320.0	279.0		12.9
Average	10.4	5.8	3.1	4.0	8.1	17.9	49.7	194.1	399.2	258.4	89.4	26.6
Maximum	68.6	35.7	16.7	16.2	22.4	86.4	223.0	469.0	1010.0	655.0	335.0	128.0
Minimum	0.0	0.0	0.0	0.0	0.8	2.9	6.9	9.3	6.4	16.1	1.6	1.0

6.2.3 Peak Flow Estimation for the proposed Perseus Project

Peak flows/discharges were determined at five locations downstream of the proposed mine infrastructure using the Rational Method, as discussed below.

6.2.3.1 Methodology

The Rational Method was selected for peak flow estimation for the following reasons:

- It is a well-established method that can be applied to a wide range of catchments, including those at the site;
- The required input parameters can be obtained/estimated from the data available for the site; and
- Initial estimates for peak flows can be obtained using limited available data - these can subsequently be worked up into more detail as required as a project progresses and/or more data become available.

6.2.3.2 Rational Method

The Rational Method formula is given as:

$$Q_p = 2.78CiA$$

Where:

Qp = design peak runoff (l/s);

C = runoff coefficient (dimensionless), which is dependent on the catchment characteristics;

i = rainfall intensity for the design return period (in mm/hr) and for the critical storm duration for the catchment; and

A = total catchment area being drained (ha).

6.2.3.3 Walkover surveys in July 2014 and January 2015

Anecdotal information obtained during the walkover surveys helped to inform the determination of parameters for input into the Rational Method, and provided context for the results. It is understood that:

- The monitoring plan (see below) includes the collection of spot flow values on a daily or weekly basis along watercourses in the vicinity of the site, as documented in the site monitoring plan, however with the exception of a perennial watercourse located to the south of the TSF valley, these were dry at the time of the January 2015 walkover survey;

- Many of the ephemeral watercourses in the vicinity of the site are poorly defined and were barely discernible at the time of the walkover surveys;
- Infiltration, at least during the dry season, appears to be rapid;
- There is no primary rainforest in the area. Land use varies between secondary forest, savannah, areas cleared for small scale agriculture, bare earth and developed area (villages and former mining development); and
- It is understood that the heap leach pads associated with previous mining operations are now 'barren' of leachable material and that runoff from the historic leach pads is routed to the natural drainage system.

6.2.3.4 Catchment Areas

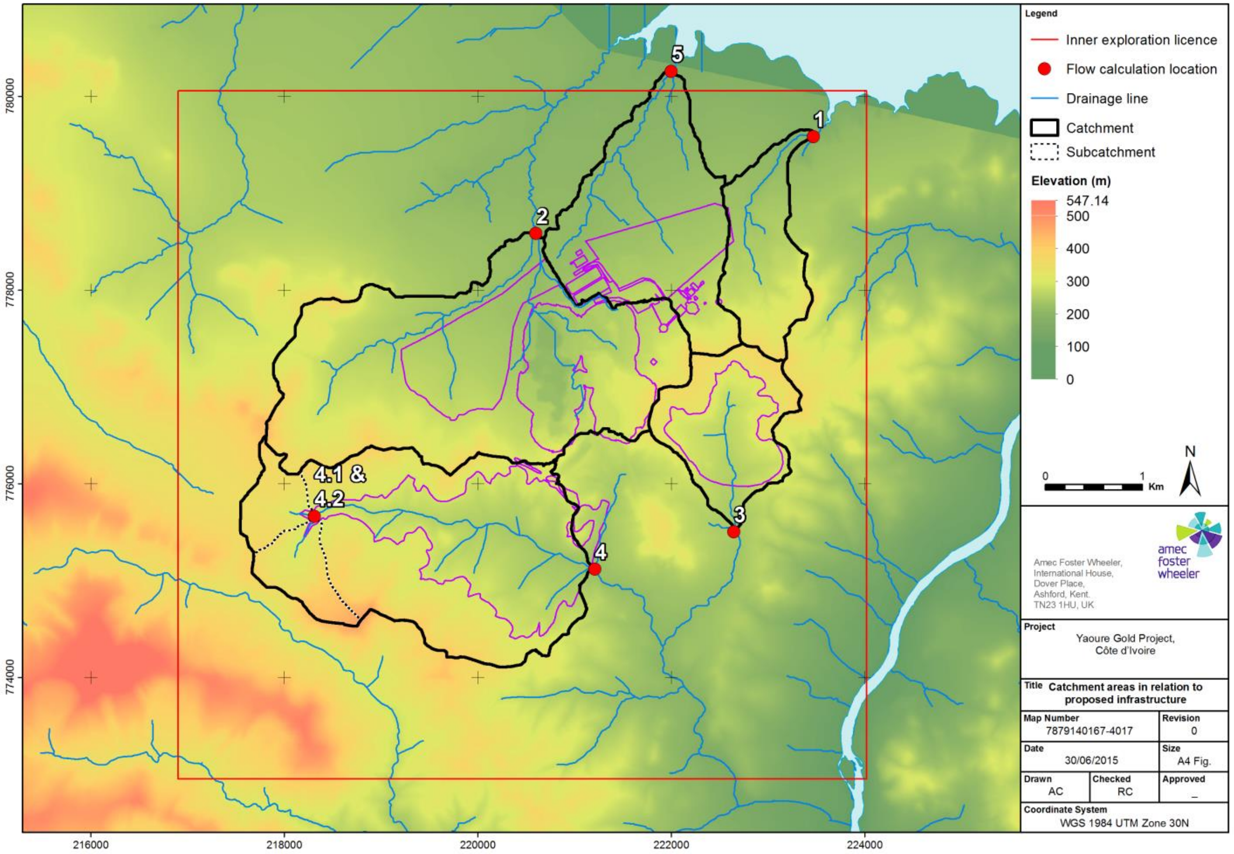
Watersheds and drainage catchments were delineated in GIS using ArcHydro software. Once the watersheds had been delineated, the locations at which peak flows would be calculated were determined.

The locations were selected so as to ensure that all rain falling on or upstream of the proposed mine infrastructure would be covered. Catchment and flow location selection considerations, including the infrastructure within each catchment, are presented in Table 6-13 below. Catchments, flow locations, provisional infrastructure locations and drainage routes are presented in Figure 6-44 below.

Table 6-13 Catchment and flow location selection considerations

Catchment No.	Infrastructure within catchment	Flow location considerations
1	• (Some of) Waste Rock Dump B	Located sufficiently downstream so as to capture all run-off from Waste Rock Dump B, but upstream of a small confluence from which flows are not of interest.
2	• Open pit • Angovia Waste Dump • Some of the proposed plant site • Some of the former heap leach area	Located at the bridge crossing for the existing road between the Angovia settlement and the Kossou Dam. Located just downstream of a sub-catchment confluence so as to capture flows from both the Angovia Waste dump and the proposed pits.
3	• Waste Dump (C)	Located upstream of a confluence with a small tributary from which flows are not of interest. The small portion of Waste Dump C which appears to be outside of the catchment (to the south east) does actually drain to this same watercourse, but does so just downstream of the confluence, hence appearing to be outside of catchment 3.
4	• TSF	Located upstream of a nearby tributary that will not be contributing flow to the TSF.
5	• Proposed plant site • Low grade stockpile • Waste Rock Dump B • Existing Office Buildings and water ponds • Former heap leach and ponds	Located downstream of the site so as to capture several smaller flow paths originating from the site in one catchment.

Figure 6-4 Catchments, flow locations, provisional infrastructure locations and drainage routes



Source: Based upon LiDAR data and a provisional infrastructure plan provided by Perseus/Tetratech

As per the delineation of the sub-catchments, the drainage routes indicated in Figure 6-4 were also determined using ArcHydro software in ArcGIS. These indicate potential drainage routes, which may be associated with overland flow paths, rills, gullies and/or channels, depending upon the upstream catchment characteristics, such as catchment size, ground cover and slope.

6.2.3.5 Runoff coefficient C

The dimensionless runoff coefficient C in the Rational Method is dependent on the catchment characteristics, such as ground cover, soil type, relief, and antecedent conditions. For this study, C was determined using professional judgement based upon visual inspection of aerial photography and 'Landsat' data obtained from the United States Geological Survey (USGS) on Normalised Difference Vegetation Index (NDVI) (for ground cover type and vegetation coverage), combined with general consideration of the soil type (not too heavy, but also not highly permeable) and knowledge of the relatively low relief in the area of interest (from LiDAR digital elevation model data). This was further supported by information obtained during the site visit, and judgement on the antecedent conditions likely to be present following the peak of the wet season, when the peak flows are likely to occur.

Estimated runoff coefficients are presented in Table 6-14 below.

Table 6-14 Run-off coefficients for use in the Rational Method

Parameter	Catchment ID				
	1	2	3	4	5
Runoff coefficient C (initial estimate) (dimensionless)	0.25	0.3	0.25	0.3 (peak)[1] 0.2 (WBM)[2]	0.4

[1] Runoff coefficient of 0.3 recommended for the TSF catchment for use in the Rational Method to calculate peak flow.
[2] Runoff coefficient of 0.2 recommended for the TSF catchment for use in water balance modelling of the TSF.

As indicated in the notes of Table 6-14, while a runoff coefficient of 0.3 has been used for assessment of peak flow at the TSF catchment outlet, this is considered conservative since the TSF catchment is the most densely vegetated (according to the aerial photography and Landsat NDVI imagery). This is considered appropriate for peak runoff calculations. However, for water balance calculations, which need to consider the resource element to inform make-up water requirements (assuming TSF catchment runoff drains to the TSF and will not be intercepted) a runoff coefficient of 0.2 is recommended.

6.2.3.6 Rainfall Intensity

Rainfall intensity was determined from IDF curves generated using rainfall data from the Bouaflé weather station and the formula of Sherman (1931), as discussed in the accompanying Climate Report (Amec Foster Wheeler, 2015). The IDF data used in this study and corresponding curves are presented below in Table 6-15.

Table 6-15 IDF results (rainfall intensity in mm/hr)

Return Period (years)	Rainfall intensity (mm/hr)								
	Duration (mins)								
	5	**10**	**20**	**30**	**60**	**120**	**180**	**720**	**1440**
100	191.5	172.7	157.4	124.8	89.1	57.5	42.9	13.9	9.2
1,000	249.4	224.8	204.9	162.5	116.0	74.9	55.9	18.1	9.9

6.2.3.7 Critical Storm Duration

The peak flow for a catchment occurs when the entire catchment is contributing flow from rainfall. The duration of the storm for which the peak flow rate will occur is known as the critical storm duration, which is generally considered equal to the 'time of concentration'.

The time of concentration (T_c) for a catchment is defined as:

- The time taken for water to flow from the most remote point on the catchment to the point of interest; and/or
- The time taken from the start of a rainfall event until all of the catchment is simultaneously contributing to flow at the point of interest.

Time of concentration can be estimated using a number of methods. For this study, the Bransby Williams method was used, which is a commonly used method and considered to be suitable in this instance. Times of concentration were cross-checked against values obtained using other methods, including a simple areal-velocity calculation and the Kerby and Kirpich methods. All of the Tc values were found to be comparable.

The Bransby Williams method is as:

$$T_c = \frac{58.5L}{A^{0.1}S^{0.2}}$$

Where:

L is the network length (km);

A is the catchment area (km2); and

S is the slope (m/km).

L is determined by the longest flow path in the catchment, which was determined using ArcHydro software in GIS. A is the area contributing to runoff along the flow path. S is given by the difference in elevation along the longest flow path.

The input parameters for the Bransby-Williams method are presented in Table 6-16 below.

Table 6-16 Input parameters for the calculation of the time of concentration for the Bransby-Williams method

Parameter	Catchment ID				
	1	2	3	4	5
Catchment area (m^2)	1,426,348	6,926,244	1,757,128	5,959,332	3,240,352
Longest flow path/network length (km)	3.02	4.50	2.32	4.96	4.47
Elevation at the top of the longest flow path (m ASL)	388.12	377.66	382.93	463.77	274.36
Elevation at the bottom of the longest flow path (m ASL)	188.87	212.36	238.71	224.58	188.17
Slope (m/m)	0.07	0.04	0.06	0.05	0.02
Slope (m/km)	65.9	36.8	62.3	48.3	19.3

T_c values calculated using the Bransby-Williams method are presented in Table 6-17 below, together with T_c calculated using the various other methods highlighted above, ranging from simple calculations of drainage length with assumed velocities, to variations on the Kerby and Kirpich methods. The additional methods, although less suitable at the site, provide confidence in the values obtained using the Bransby-Williams method.

Table 6-17 Calculated time of concentrations

Calculation method	Catchment ID				
	1	2	3	4	5
Direct length assumed velocity (of 0.5m/s) (minutes)[1]	78	120	64	123	99
Detailed length assumed velocity of 0.5m/s (minutes)[2]	101	150	77	165	149
Bransby-Williams (minutes)	**74**	**105**	**56**	**112**	**129**
Kerby-Kirpich (minutes)[3]	Location at which flow becomes channelised required- not known at this stage				
Kerby only (all overland) (minutes)[4]	75	104	81	123	105
Kirpich only (all overland) (minutes)[5]	56	96	47	93	122
Kirpich only (all channel flow) (minutes)[6]	28	48	23	47	61
Time of concentration used (Bransby-Williams) (minutes)	**74**	**105**	**56**	**112**	**129**

[1]-For the direct length assumed velocity method, the time of concentration is simply estimated by dividing the direct 'as the crow flies' distance between the top and bottom of the catchment by an assumed velocity of flow. This gives a 'ball park' estimate of likely time of concentration.

[2] For the detailed length assumed velocity method, the time of concentration is simply estimated by dividing the 'detailed' longest flow path distance between the top and bottom of the catchment by an assumed velocity of flow. This gives an upper 'ball park' estimate of likely time of concentration.

[3] The Kerby-Kirpich method involves addition of the time of concentration calculated for overland flow using the Kerby method to the time of concentration calculated for channel flow using the Kirpich method. This method can be applied to catchments between 1.61 and 80km^2, main channel lengths between 1.6 and 80km and slopes between 0.002 and 0.02. However, the determination of a location at which overland flow becomes channel flow is required. This is currently unknown and therefore this method has not been applied.

[4] The Kerby method is meant for overland flow in small drainage basins only. The upper limit should be a flow length of about 305m. All catchments, flow lengths and slopes are too large and too steep to rely upon values determined by the Kerby method only. Values are presented here for indicative purposes only. The Kerby Method also requires the estimate of a dimensionless retardance co-efficient (N), which is based up on the ground cover (this should not be interpolated between tabulated values).

[5] The Kirpich method is meant for channel flow, but can also be used for overland flow or flow in a natural grass channel by applying an adjustment factor. The method can only be applied to catchments of certain sizes, channel lengths and channel slopes. All catchments are too large for the application of this method alone. Values are presented here for indicative purposes only.

[6] The Kirpich method yields very conservative or short times of concentration that result in high peak runoff rates, especially from the rational method. This method should only be used if the available data are limited to watershed length and slope, or the method is specified. All catchments are too large for the application of this method alone. Values are presented here for indicative purposes only.

6.2.3.8 Rational Method results

The input parameters used in the Rational Method and the peak flow results for the 100 and 1,000 year return periods are presented in Table 6-18 below.

Table 6-18 Rational Method input parameters and results for the 100 and 1000 year return period events

Parameter	Catchment ID				
	1	2	3	4	5
Catchment Area (m^2)	1,426,348	6,926,244	1,757,128	5,959,332	3,240,352
Runoff coefficient C (initial estimate) (dimensionless)	0.25	0.3	0.25	0.3	0.4
Time of concentration/critical storm duration (minutes)	74	105	56	112	129
Rainfall intensity – 100 year return period (mm/hr)	82	65	94	62	55
Rainfall intensity – 1000 year return period (mm/hr)	106	85	122	81	75
Peak flow – 100 year return period (m^3/s)	8	38	11	31	20
Peak flow – 1000 year return period (m^3/s)	11	49	15	40	27

The results presented in Table 6-17 and Table 6-18 confirm that not-insignificant peak flows could occur from any of the catchments at the site, and further consideration will be required as the infrastructure plan for the mine is progressed. The flows presented in Table 6-18 do not include an allowance for climate change, or for the proposed development at the site (i.e. to reflect changes in landcover). Further analysis was undertaken, as discussed below, to take account of the most significant changes that would occur at the site, which will be associated with the pits in catchment 2 and the TSF in catchment 4.

6.2.4 Developed mine scenario

6.2.4.1 Introduction

For the developed mine scenario, there are a number of additional hydrological considerations which will need to be taken into account as the mine infrastructure proposals progress. The most significant of these, associated with the pits and the TSF, i.e. catchments 2 and 4 respectively, are discussed in the Section below.

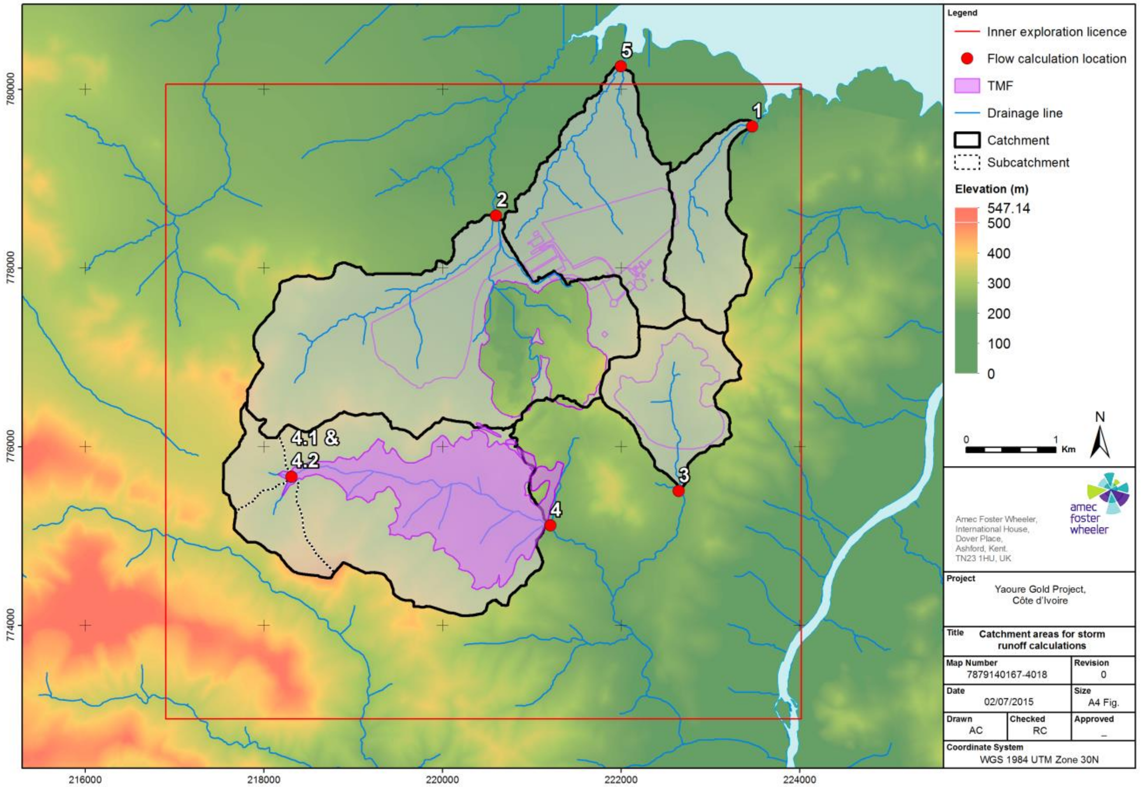
6.2.4.2 Changes to catchment characteristics and sub-catchments for TSF diversions

For the developed mine scenario, the area of catchment 2 will be reduced by the size of the pits, and catchment 4 will be reduced by the area of the TSF. The resulting catchments have been referred to as Catchments 2a and 4a respectively in this report.

Once the TSF is fully developed, the TSF catchment (4a) will effectively comprise a number of smaller sub-catchments either reporting to the TSF, or a diversion channel around its edge. Peak flow calculations were therefore also carried out for two representative sub-catchments in the TSF catchment, to provide information as to the likely magnitude of flows for assessing diversion channel feasibility with respect to the likely capacity required. Sub-catchments at the upstream end of the TSF were selected, as two of the largest sub-catchments in the 4a catchment.

The amended catchments 2a and 4a are shown in Figure 6-55 below, together with the 4.1 and 4.2 sub-catchments, and the original catchments 1-5.

Figure 6-5 Amended catchments 2a and 4a (greyed), and sub-catchments 4.1 and 4.2



Source: Based upon LiDAR data provided by Perseus on DATE and a provisional infrastructure plan provided by Perseus on date (Feb/early March 2015)

The Rational Method input parameters and results for the 100 and 1,000 year return period events for catchments 2 and 4 are reproduced in Table 6-19 below, together with the values for the amended 2a catchments, and the 4.1 and 4.2 sub-catchments. A value for 4a has not been presented, owing to the fact that two diversion channels would likely be required, one to the north and the other to the south of the TSF.

Table 6-19 Rational Method input parameters and results for the 100 and 1000 year return period events for the amended catchments and sub-catchments of catchments 2 and 4

Parameter	Catchment ID				
	2	**2a**	**4**	**4.1**	**4.2**
Catchment Area (m^2)	6,926,244	5,301,289	5,959,332	486,836	579,504
Longest flow path (total) (km)	4.50	4.50	4.96	1.19	1.57
Elevation at the top of the longest flow path	377.66	377.66	463.77	367.55	463.77
Elevation at the bottom of the longest flow path	212.36	212.36	224.58	284.76	284.76
Slope (m/m)	0.04	0.04	0.05	0.07	0.11
Runoff coefficient C (initial estimate) (dimensionless)	0.3	0.3	0.3	0.2	0.2
Time of concentration/critical storm duration (minutes)	105	108	112	32	38
Rainfall intensity – 100 year return period (mm/hr)	65	64	62	122	116
Rainfall intensity – 1000 year return period (mm/hr)	85	83	81	159	151
Peak flow – 100 year return period (m^3/s)	38	31	31	3	4
Peak flow – 1000 year return period (m^3/s)	49	37	40	4	5

The estimated peak flows in Table 6-19 indicate that, at any point in the lifetime of the pits, peak flows in Catchment 2 would be expected to be between the estimate for 2a (the smallest catchment footprint during the lifetime of the mine) and that for the existing catchment 2 (the largest catchment footprint during the lifetime of the mine), depending upon the stage of pit development, i.e. between 31 and 38 m^3/s for the 100 year event.

It can be seen that, even with the TSF at its full extent (covering a total area of approximately 2.31 km^2), a significant proportion of the upstream catchment will remain (approximately 3.65 km^2). This is approximately 60% of original area of catchment 4 (approximately 5.96 km^2), indicating that diversion along the margins of the TSF would likely be required in order to ensure that sufficient control on water volumes and management requirements within the TSF are facilitated.

Initial estimates for the required capacity of the diversion channel have been made based upon the characteristics of the upstream sub-catchments that would otherwise report to the TSF (catchments 4.1 and 4.2).

Sub-catchments 4.1 and 4.2, at the upstream end of the TSF have been estimated to produce peak flows in the region of 4 to 5 m^3/s, for both the 100 year and 1,000 year events. This indicates that a diversion channel with at least this capacity would likely be required.

6.2.4.3 Results summary

Peak flows calculated using the rational method, for all catchments, amended catchments and sub-catchments considered in this report and for all return periods are provided in Table 6-20 below.

Table 6-20 Summary of peak flow estimates for all catchments, amended catchments and sub-catchments, for all return periods

Peak flows (m^3/s)								
Return period (year)	**Catchment**							
	1	**2**	**3**	**4**	**5**	**2a**	**4.1**	**4.2**
100	8	38	11	31	20	28	3	4
1,000	11	49	15	40	26	37	4	5

6.2.5 Current monitoring

A monitoring programme for water quality, flow and levels was prepared and instigated by Perseus in November 2014. Flow monitoring commenced in December 2014. Data collected through to April 2015 has coincided with the dry season and so many ephemeral streams have been dry or nearly so. Details can be found in the Baseline Study (**Error! Reference source not found.**). Monitoring sites are shown on Figure 6-4.

Flows recorded have shown the following ranges:

- S1 0.001 – 0.107 m^3/s;
- S5 dry – 0.019 m^3/s;
- S8 dry – 0.314 m^3/s;
- S12 0.074 – 0.302 m^3/s; and
- SW4 dry – 0.019 m^3/s.

Of note is that on the basis of the available flow monitoring data, most of the monitoring locations have been dry for much or all of the time due to the start of monitoring coinciding with the dry season. Accordingly it is not possible to relate observed rainfall with flows for a complete season cycle to develop a natural water balance from observed data.

It is however possible to generate estimates of peak flows from the historical rainfall record together with estimates of run-off coefficient. Table 6-18 is taken from **Error! Reference source not found.** and shows derived peak flows for the various sub-catchments identified for the project.

6.2.6 Stuquo of Surface Water Quality

6.2.6.1 Historical (to 2013) Surface Water Quality

A description of the surface water and hydrological regime associated with the wider Project area is included in Section 6.2 of the ESIA document. This section provides an overview of average water qualities obtained from previous monitoring programs. Surface water monitoring was undertaken historically during periods between 2006 and 2013 with more recent monitoring commencing in late 2014 (see next section). Historical surface water monitoring points are given in Table 6-221. Historical monitoring was sporadic and thus for some monitoring points or parameters, very limited data was available. A statistical summary of the historical surface water quality results is provided in Table 6-22 and for bacteriological monitoring done in 2009 in Table 6-23. Where monitoring data was unreliable and limited, it was not included in the table. The water quality results are compared against the CIAPOL Effluent limits and the WHO Guidelines for Drinking Water Quality, Fourth Edition, 2011, are also included in Table 6-25. Results exceeding the WHO limits for drinking water are highlighted in red.

Table 6-221 Historical Surface Water Monitoring Points (up to 2013)

Code	Name	Description	GPS Coordinates (UTM)	
			North	East
SW1	Wintin-wintin Stream I	Upstream of Wintin-wintin before Allahou Bazi Village	778394	220478
SW2	Wintin-wintin Stream II	Downstream of Wintin-wintin upstream of Bandama River confluence	779991	220960
SW3	Bandama River I	Downstream of Bandama River at Clement Bambakro Village	764899	220575
SW4	N'Zué blé Stream	N'Zué blé Stream upstream of Patizia II Village	772564	222909
SW5	Palé Stream	Palé Stream downstream of Patizia I Village and downstream of Kouakougnanou	770294	220916
SW6	Bandama River II	Upstream of Bandama River below the dam wall	777398	225794

Table 6-222 Statistical Summary of Historical (to 2013) Surface Water Quality Monitoring Results

		pH	Turbidity (NTU)	Conductivity (µS)	Suspended matter (mg/L)	Dissolved solids	Ca (mg/L)	Mg (mg/L)	Na+ (mg/L)	K+ (mg/L)	Dissolved oxygen	PO_4 (mg/L)	NO_3 (mg/l N)	SO_4 (mg/L)
WHO 2011 Potable Water Guideline Limits			5						50				11.3	
SW1	MIN	6.63	1.2	30.3	0	173	25.7	12.8	7.3	0.917	2.1	<0.02	0.001668	0.9
SW1	MEAN	7.28	136	304	15	211	32.8	40.6	17.7	3.30	2.77	<0.02	<0.177	16.4
SW1	MAX	8	533	1130	35	242	42.5	111.72	25.5	7.7	3.9	<0.02	0.47	40.79
SW1	COUNT	10	10	9	5	3	7	7	7	6	3	1	6	6
SW2	MIN	6.9	6.21	51.9	0.002		8.8176	0.47	10.225	<0.001		<0.02	0.000552	1.61
SW2	MEAN	7.67	84.1	461	13.8		42.4	57.3	26.7	0.385		<0.02	6.03	4.83
SW2	MAX	8.5	300	1183	50		68	103.9	47.6	1		<0.02	18.1	8
SW2	COUNT	9	8	6	6	0	5	5	4	3	0	1	3	3
SW3	MIN	6.7	0.8	7.2	0	38	5.4	1.2516	3.37	0.224	2.4	0.03	0.000928	0.1
SW3	MEAN	7.20	2.81	61.6	5.33	55.3	6.99	5.67	6.45	2.83	3	0.03	0.442	<2.27
SW3	MAX	8.1	6.15	127.3	10	78	9.8	16.278	10.2	4.2	4	0.03	1.02	3.94
SW3	COUNT	8	8	7	3	3	6	6	7	6	3	1	6	5
SW4	MIN	7.16	0.8	71.1	0	399	20.8416	3.6228	3.732	0.29	2.5	0.05	0.001008	2.25
SW4	MEAN	7.52	10.3	318	8	400	34.8	31.4	12.0	1.02	3.2	0.05	<0.337	5.29
SW4	MAX	7.94	25.5	822	15	400	75.1	59.0148	23	1.6	3.9	0.05	0.95	7.8
SW4	COUNT	7	7	6	3	2	5	5	6	5	2	1	5	4

		Mn Total (mg/L)	Cl- (mg/L)	Fe tot (mg/L)	Hardness (mg/L $CaCO_3$)	Cu tot (mg/L)	NH_4 (mg/L)	Ni tot (mg/L)	Pb (mg/L)	Zn (mg/L)	Hg (mg/L)	As (mg/L)	CO_3 (mg/L)	HCO_3 (mg/L)	CN- free (mg/L)	CN- tot (mg/L)
WHO 2011 Potable Water Guideline Limits						2		0.07	0.01		0.006	0.01				
SW1	MIN	0.013	0.45	0.182	90	<0.01	0.09	<0.001	0.084	0.027	<0.001	<0.001	<2.5	82.96	<0.003	<0.01
SW1	MEAN	0.289	8.754	1.6372	140.8	<0.0815	1.85	<0.0415	0.084	0.059	<0.00125	<0.00588	<2.75	162	<0.0533	<0.0543
SW1	MAX	0.836	16.02	4.89	205	0.282	3.65	0.082	0.084	0.091	0.002	0.0183	<3	232	0.1	<0.1
SW1	COUNT	9	5	10	7	4	3	2	1	2	4	6	2	4	7	7
SW2	MIN	0.041	0.45	0.188	14.43	<0.02	1.8	<0.001	0.05	0.005	<0.001	<0.002	<3	43.92	<0.01	<0.01
SW2	MEAN	0.289	7.74	0.506	126	0.0445	3.04	<0.05	0.05	0.038	<0.001	<0.011	<3	167	<0.0567	<0.08
SW2	MAX	1.317	15.02	1.3	195	0.073	4.27	0.099	0.05	0.071	<0.001	0.021	<3	234	<0.1	0.22
SW2	COUNT	7	2	7	5	4	2	2	1	2	1	3	1	3	9	9
SW3	MIN	0.041	0.35	0.115	10.66	<0.02	0.04	<0.001	0.119	0.164	<0.001	<0.001	<2.5	24.4	<0.003	<0.003
SW3	MEAN	<0.153	4.11	0.359	40.2	<0.025	1.23	<0.0785	0.119	0.164	<0.00125	<0.0032	<2.75	73.1	<0.0486	<0.0486
SW3	MAX	0.39	11.01	1.547	86.27	0.03	1.85	0.156	0.119	0.164	<0.002	<0.01	<3	148.84	<0.1	<0.1
SW3	COUNT	7	5	8	6	2	3	2	1	1	4	5	2	4	5	5
SW4	MIN	<0.05	0.4	<0.01	21.89	<0.02	0.036	<0.001	0.035	0.006	<0.001	<0.001	<2.5	39.04	<0.003	<0.003
SW4	MEAN	<0.129	7.5	<0.250	159	<0.035	0.695	<0.07	0.035	0.017	<0.00167	<0.0035	<2.75	88.4	<0.0486	<0.0486
SW4	MAX	0.198	12.8	0.685	363.3	0.05	2	0.139	0.035	0.028	<0.002	<0.01	<3	148	<0.1	<0.1
SW4	COUNT	6	4	7	5	2	3	2	1	2	3	4	2	3	5	5

Figure 6-53 Bacteriological Monitoring, 2009

		E.Coli (UFC/mL)	F.Coliforms (UFC/mL)	Salmonella (UFC/mL)	Total Coliforms ((UFC/mL)	Staphylacocci (UFC/mL)	Streptococci (UFC/mL)
SW1	26/05/2009	Absent	-	Absent	Absent	$3x10^5$	0
SW2	26/05/2009	Absent	-	Absent	48.10^7	$6.8x10^4$	0
SW3	28/05/2009	Absent	-	Absent	785.10^3	$65x10^3$	$418x10^2$
SW4	26/05/2009	Absent	-	Absent	Absent	$146x10^2$	0
SW5	28/05/2009	Absent	-	Absent	Absent	$33x10^2$	0

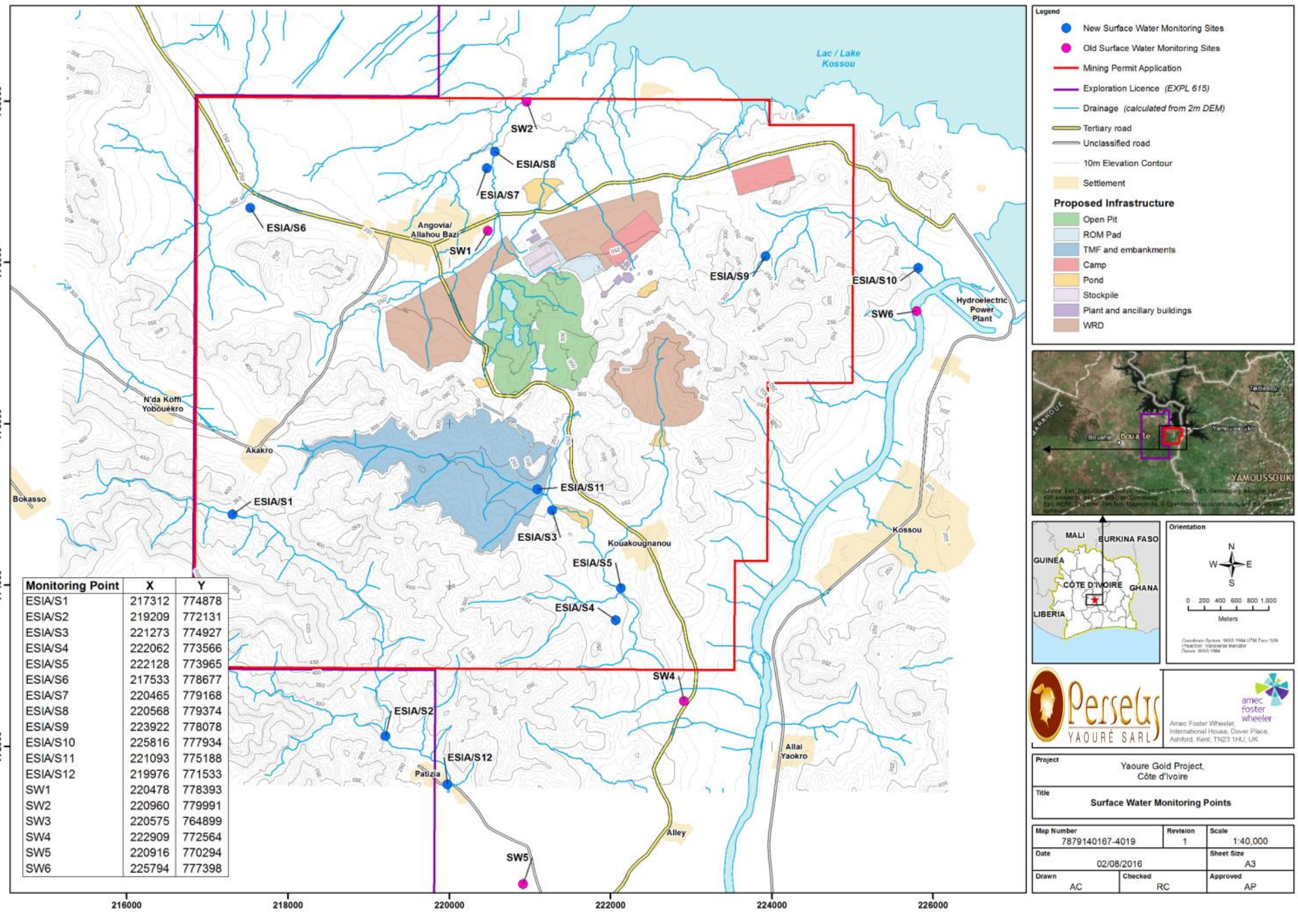
6.2.6.2 Recent (from 2014) ESIA Surface Water Quality

A total of 22 surface water samples had been collected at the time of compiling the ESIA report for measurement of field parameters and laboratory analysis in four campaigns during December 2014, January 2015, February 2015 and March 2015. The samples were obtained from nine different surface monitoring sites within the Yaouré Project (see Table 6-24 and Figure 6-). A statistical summary of the data is provided in Table 6-. This summary takes consideration of the average values across all sampling locations. Subsequently a full 12-month cycle of sampling and analysis has been completed and is reported in the EMS of Yaoure.

Table 6-24 Recent Surface Water Monitiring Points (from 2014 ESIA)

Monitoring site	Easting	Northing
ESIA/S1	217312	774878
ESIA/S12	219976	771533
ESIA/S5	222128	773965
ESIA/S8	220568	779374
SW/4	222909	772564
SW/6	225794	777398
YSP	220834	777088
YCP	220583	777209
YNP	220719	777535

Figure 6-6 Historical and 2014 ESIA Surface Water Monitoring Points[4]



Monitoring Point	X	Y
ESIA/S1	217312	774878
ESIA/S2	219209	772131
ESIA/S3	221273	774927
ESIA/S4	222062	773566
ESIA/S5	222128	773965
ESIA/S6	217533	778677
ESIA/S7	220465	779168
ESIA/S8	220568	779374
ESIA/S9	223922	778078
ESIA/S10	225816	777934
ESIA/S11	221093	775188
ESIA/S12	219976	771533
SW1	220478	778393
SW2	220960	779991
SW3	220575	764899
SW4	222909	772564
SW5	220916	770294
SW6	225794	777398

[4] SW3 is located on the Bandama River, but off the map to the south at the bridge of the Yarko-Bouafle road close to Bozi village.

6.2.6.3 Physical Characteristics of Yaouré Surface Water (from 2014)

The samples from Yaouré Project area have pH values from field measurements ranging from 7.1 – 8.4, with a mean value of 7.66, indicating mildly neutral waters. The pH values are within the limits stipulated by CIAPOL (5.5 – 8.5).

The total suspended solids (TSS) range between <1 and 167 mg/l. The limits stipulated by CIAPOL are 50 mg/l if the discharge load exceeds 15 kg/day, otherwise 150 mg/l – 3 samples exceed the lower limit of 50mg/l, of which one is >150mg/l. The highest at 167 mg/l is from SW6 in the Bandama River below the dam wall on 18 December 2014. Subsequent values from that site were between 17 and 85 mg/l, indicating variation due to discharge release and disturbance, and possibly the sampling process. The other value over 50 mg/l was 129 mg/l from the north pond in the old open pits (YNP) where high TSS can be expected. Erosion control measures will have to be put in place to protect the water resources from additional silt loads where necessary.

Electrical conductivity (EC) values varied from 7.7 to 74.5 mS/m, averaging 29.0 mS/m. The calculated hardness values vary from 22 – 364 mg/l, with a mean value of 144 mg/l. EC is directly linked to TSS, therefore an increase in TSS will lead to an increase in EC. No WHO or CIAPOL limit is available.

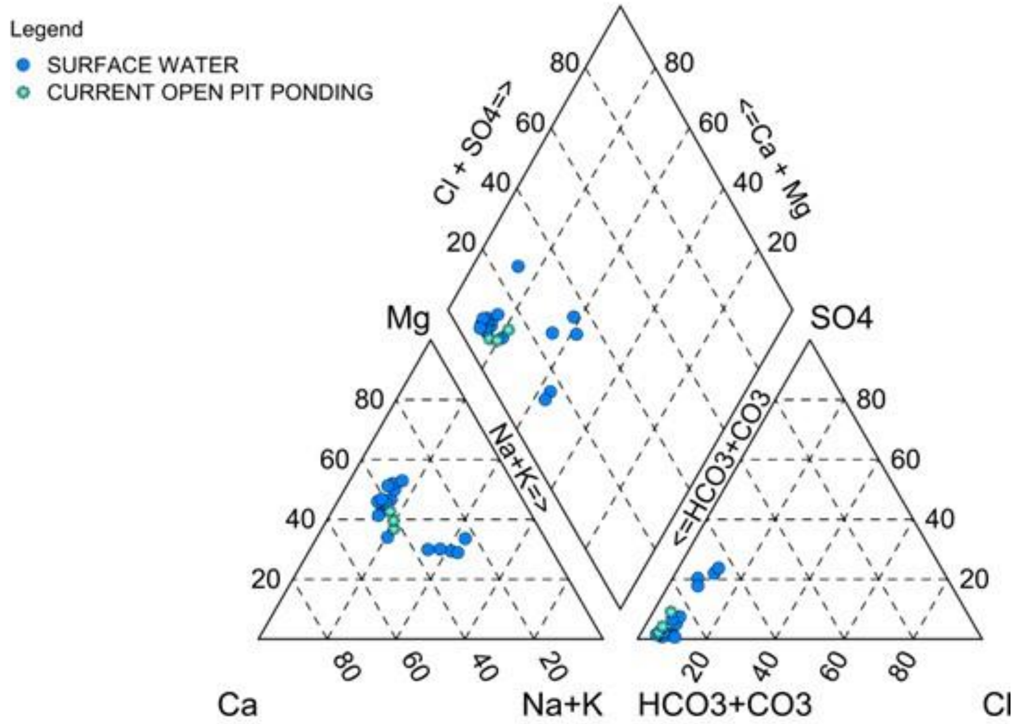
Plotting the major cations Na^+, K^+, Ca^{2+}, Mg^{2+} and major anions HCO_3^-, CO_3^{2-}, SO_4^{2-} and Cl^- on a trilinear Piper diagram assists in classifying the hydrochemical facies of water samples. The majority of surface water samples plot as Mg-Ca-HCO_3 water type (refer to Figure 6-7). The magnesium, calcium and bicarbonate values are naturally elevated as a result of the natural geology.

Table 6-25 Statistical Summary of Surface Water Quality Data: December 2014 – March 2015

Parameter	Units	Min	Average	Max	Count	WHO 2011 Guideline
Lab pH		7.1	7.66	8.4	20	NGV
Turbidity	NTU	1.2	35.5	229	20	NGV
Conductivity	mS/m	7.7	29.0	74.5	10	NGV
Total Suspended Solids at 103-105'C	mg/L	<1	29.7	167	20	NGV
Carbonate Alkalinity as CO3	mg/L	<1	<1	1	20	NGV
Total Alkalinity as CaCO3	mg/L	27	151	377	20	NGV
Bicarbonate Alkalinity as HC03	mg/L	33.0	184	460	20	NGV
Hardness by Calculation	mg/L	22	144	364	20	NGV
Calcium dissolved	mg/L	3	26.3	66	20	NGV
Chloride	mg/L	1.6	7.66	17.3	20	NGV
Fluoride by ISE	mg/L	<0.1	<0.11	0.2	10	1.5
Magnesium dissolved	mg/L	2.5	17.4	46.8	20	NGV
Potassium dissolved	mg/L	0.2	1.65	8.6	20	NGV
Sodium dissolved	mg/L	4.4	9.82	21	20	NGV
Sulphate	mg/L	<1	<4.35	15	20	NGV
Total Cyanide	mg/L	<0.005	<0.005	<0.005	9	NGV
Free Cyanide	mg/L	<0.005	<0.005	<0.005	2	NGV
Weak Acid Dissociable Cyanide	mg/L	<0.005	<0.005	<0.005	2	NGV
Ammonia as N	mg/L	0.02	0.0944	0.19	16	NGV
Ammonium as NH4	mg/L	<0.1	<0.12	0.2	10	NGV
Nitrate	mg/L	<0.06	0.339	1.32	20	50
Nitrite	mg/L	<0.05	<0.0545	0.11	20	3
Phosphate	mg/L	<0.02	<0.038	0.09	10	NGV
Phosphorus dissolved	mg/L	<0.05	<0.0557	0.08	7	NGV
Phenol	mg/L	<0.1	<0.1	0.1	10	NGV
Biochemical Oxygen Demand (BOD5)	mg/L	<5	<6.55	13	20	NGV
Chemical Oxygen Demand	mg/L	<25	<26.3	39	20	NGV
Aluminium dissolved	mg/L	<0.03	<0.03	0.03	20	NGV

Parameter	Units	Min	Average	Max	Count	WHO 2011 Guideline
Antimony dissolved	mg/L	<0.0001	<0.000857	0.003	7	0.02
Arsenic dissolved	mg/L	<0.0005	<0.000675	0.0015	20	0.01
Barium dissolved	mg/L	0.001	0.0158	0.041	20	0.7
Beryllium dissolved	mg/L	<0.0005	<0.0005	<0.0005	7	NGV
Bismuth dissolved	mg/L	<0.1	<0.1	<0.1	7	NGV
Boron dissolved	mg/L	<0.02	<0.02	0.02	20	2.4
Cadmium dissolved	mg/L	<0.0001	<0.000105	0.0002	20	0.003
Chromium dissolved	mg/L	<0.001	<0.0021	0.013	20	0.05
Chromium-6	mg/L	<0.04	<0.04	<0.04	20	0.05
Cobalt dissolved	mg/L	<0.001	<0.001	0.001	20	NGV
Copper dissolved	mg/L	<0.001	<0.0011	0.003	20	2
Iron dissolved	mg/L	<0.1	<0.118	0.3	17	NGV
Lead dissolved	mg/L	<0.0005	<0.00054	0.0012	20	0.01
Lithium dissolved	mg/L	<0.0005	<0.00771	0.051	7	NGV
Manganese dissolved	mg/L	<0.002	<0.0372	0.38	20	NGV
Mercury dissolved	mg/L	<0.0001	<0.0001	0.0001	20	0.006
Molybdenum dissolved	mg/L	<0.0005	<0.000814	0.0017	7	NGV
Nickel dissolved	mg/L	<0.001	<0.00235	0.006	20	0.07
Selenium dissolved	mg/L	<0.01	<0.01	<0.01	20	0.04
Silicon dissolved	mg/L	5.98	13.4	36.1	10	NGV
Silver dissolved	mg/L	<0.0001	<0.000129	0.0003	7	NGV
Strontium dissolved	mg/L	0.026	0.0774	0.169	20	NGV
Thallium dissolved	mg/L	<0.0001	<0.000114	0.0002	7	NGV
Tin dissolved	mg/L	<0.0002	<0.000643	0.001	7	NGV
Titanium dissolved	mg/L	0.0021	0.00431	0.0092	7	NGV
Uranium dissolved	mg/L	<0.0001	<0.000286	0.0009	7	0.03
Vanadium dissolved	mg/L	0.0015	0.00471	0.014	7	NGV
Zinc dissolved	mg/L	<0.005	<0.0052	0.007	20	NGV

Figure 6-7 Piper Diagram for Surface Water Samples



6.2.6.4 Heavy Metals Characteristics of the Yaouré Surface Water

The following summarizes heavy metals and other trace element results from the initial surface water sampling campaign, which was carried out as part of the ESIA process.

Antimony
Dissolved antimony measurements for samples range from <0.0001 to 0.003 mg/l in S6, which is below the WHO Guideline Value of 0.02 mg/l.

Arsenic
Over half of the samples had detectable measurements of dissolved arsenic. Values ranged from <0.0005 to 0.0015mg/l (open pit pond), but did not exceed the WHO Guideline Value of 0.01mg/l.

Barium
Dissolved barium measurements for the samples range from 0.001- 0.041 mg/l at SW6, which is well below the WHO Guideline Value of 0.7 mg/l.

Boron
The maximum boron value of 0.02 mg/l (also the detection limit) is well below the WHO Guideline Value of 2.4 mg/l.

Fluoride
Dissolved fluoride ranged from <0.1- 0.2 mg/l at S12, well below the WHO Guideline Value of 1.5 mg/l.

Cadmium
Values ranged from <0.0001 to 0.0002 mg/l, not exceeding the WHO Guideline Value for Drinking Water of 0.003 mg/l.

Chromium
Just over half the samples had measurable levels of dissolved chromium. The maximum chromium was 0.013 mg/l (in the open pit north pond), not exceeding the WHO Guideline value of 0.05mg/l. No other values exceeded 0.004 mg/l.

Copper
Dissolved copper exists at measurable levels in three samples. Values range from <0.001 to 0.003 mg/l at SW6, far below the WHO Guideline Value of 2 mg/l and the CIAPOL limit of 0.5 mg/l if the discharge load exceeds 5 g/day.

Iron
Iron dissolved varied between <0.1 and 0.3 mg/l. Iron total (not shown in table) ranged between 0.1 and 8.1 mg/l with 2 samples exceeding the CIAPOL limits of 5mg/l if the discharge load exceeds 5 g/day. This can be most likely attributed to the natural geology.

Lead
Detectable levels of lead have been noticed in historic water samples at SW1, SW2, SW3 and SW4, exceeding the WHO Guideline Value for Drinking Water of 0.01 mg/l but not the CIAPOL limit of 0.5 mg/l if the discharge load exceeds 5 g/day. Two samples associated with the ESIA water quality-sampling run had detectable levels of lead, although neither exceeded the WHO Guideline Value for Drinking Water of 0.01 mg/l and the CIAPOL limit of 0.5 mg/l if the discharge load exceeds 5 g/day. The maximum detection was 0.0012 mg/l (open pit north pond).

Manganese
Manganese values ranged between <0.002 and 0.38 mg/l, with an average of <0.0372 mg/l, which is well below the CIAPOL limits of 1mg/l if the discharge load exceeds 10 g/day.

Mercury
Dissolved mercury was not detected in any of the ESIA samples. Historic samples indicated some elevated levels of mercury at SW1, although on average the levels were well below the WHO Guideline Value for Drinking Water of 0.006 mg/l.

Nickel
Dissolved nickel ranges between <0.001 - 0.006 mg/l. These values are below the WHO Guideline Value of 0.07 mg/l and the CIAPOL limit of 0.5 mg/l if the discharge load exceeds 5 g/day.

Selenium
Dissolved selenium was not at detectable levels in any of the samples.

Uranium
Dissolved uranium exists at measurable levels in four of seven samples. Values range from <0.0001 – 0.0009 mg/l which is well below the WHO Guideline Value of 0.03 mg/l.
Zinc
Zinc values range between <0.005mg/l to 0.007mg/l, with an average of <0.0052mg/l.

Cyanide
All 9 samples tested had <0.005 mg/l Total Cyanide. No WHO (2011) value of cyanide is established on the basis that it ''occurs in drinking water at concentrations well below those of health concern, except in emergency situations following a spill to a water source''. The IFC Environmental, Health and Guidelines for Mining (2007) indicates that cyanide levels should not exceed 1mg/l and not more than 0.1mg/l free cyanide. The cyanide level is well within these limits.

6.2.6.5 Nutrients and Organics Characteristics of Yaouré Surface Water

Ammonia
Ammonia values for samples are all below 0.2 mg/l, which have no direct relevance to health at these levels.

Nitrite
Nitrite exists at measurable levels in only 2 of 20 samples with a maximum of 11 mg/l (S1) and these values are all below the WHO Guideline Value for Drinking Water of 3 mg/l

Nitrate
Nitrate exists at measureable levels in over half of the samples. No samples exceed the WHO Guideline Value for Drinking Water of 50 mg/l, NO_3 with the maximum being 1.32 mg/l (SW6).

Phosphate
Phosphate exists at low values ranging from <0.02 – 0.09mg/l.

Biochemical oxygen demand
Biochemical oxygen demand exists at measurable levels in 9 of 20 samples, ranging from <5 – 13 mg/l.

Chemical oxygen demand
Chemical oxygen demand ranges from <25 – 39 mg/l.

Phenol
Phenol was at measureable levels in only three samples at 0.1mg/l, which is also the detection limit.

6.3 Hydrogeology

The following is a summary of the detailed baseline data provided in **Error! Reference source not found.**.

6.3.1 Aquifers

SRK (2008) indicated that there are two main aquifer types associated with the Project:

- Shallow Weathered Aquifers: Shallower aquifers mainly associated with weathered sedimentary rock (schist) and transitions of granite. The permeability is low and porosity is weak as a result of relatively high clay content. The water table generally follows the topography. There are vertical and lateral variations in the aquifer which cause water assurance to be deemed unstable. Most of the villages draw their groundwater from this aquifer. Water quality is influenced by the high clay contents of the base rock. Due to the shallow nature of the aquifer it is at risk of pollution.

- Fractured Aquifers: These are deeper aquifers associated with geological fractures and fissures within the rock mass. The porosity is very low. Permeability is high in areas where fissuring and fracturing is dense, otherwise groundwater can be contained within fissures and fractures. The water table varies between 40 m to 60 m below surface. As far as can be established no water quality data for this aquifer are currently available. Where aquifers are connected, dewatering can lead to the formation of a drawdown cone.

6.3.2 Yaoure Project Drilling and Testing

6.3.2.1 Environmental and Geotechnical Boreholes

Groundwater environmental monitoring sites were selected to provide suitable coverage of the project area to define baseline conditions, including use of historic monitoring locations, and longer term environmental monitoring during construction and operations.

Eight geotechnical boreholes (known as 'Gash' holes and referred to as G1 through G8) were drilled between July and September 2014. The bores were advanced at 80 degrees using diamond coring. Coring started at a diameter of 96 mm (HQ) and was reduced to 75.7 mm (NQ) until completion.

In October 2014, in support of baseline monitoring, a series of eight vertical boreholes were drilled, named ESIA G1 through ESIA G8. The bores were 140 mm in diameter and were advanced by reverse circulation.

In late October and November 2014, a series of pumping and observation wells were drilled to accompany the Gash holes, designated YRC761 through YRC767. The bores were 140 mm in diameter and were advanced by reverse circulation.

Figure 6-8 shows the location of the groundwater monitoring boreholes within the overall project and surrounding area.

Figure 6-8 Topography and Drainage of the Project Locality and Current Monitoring Locations

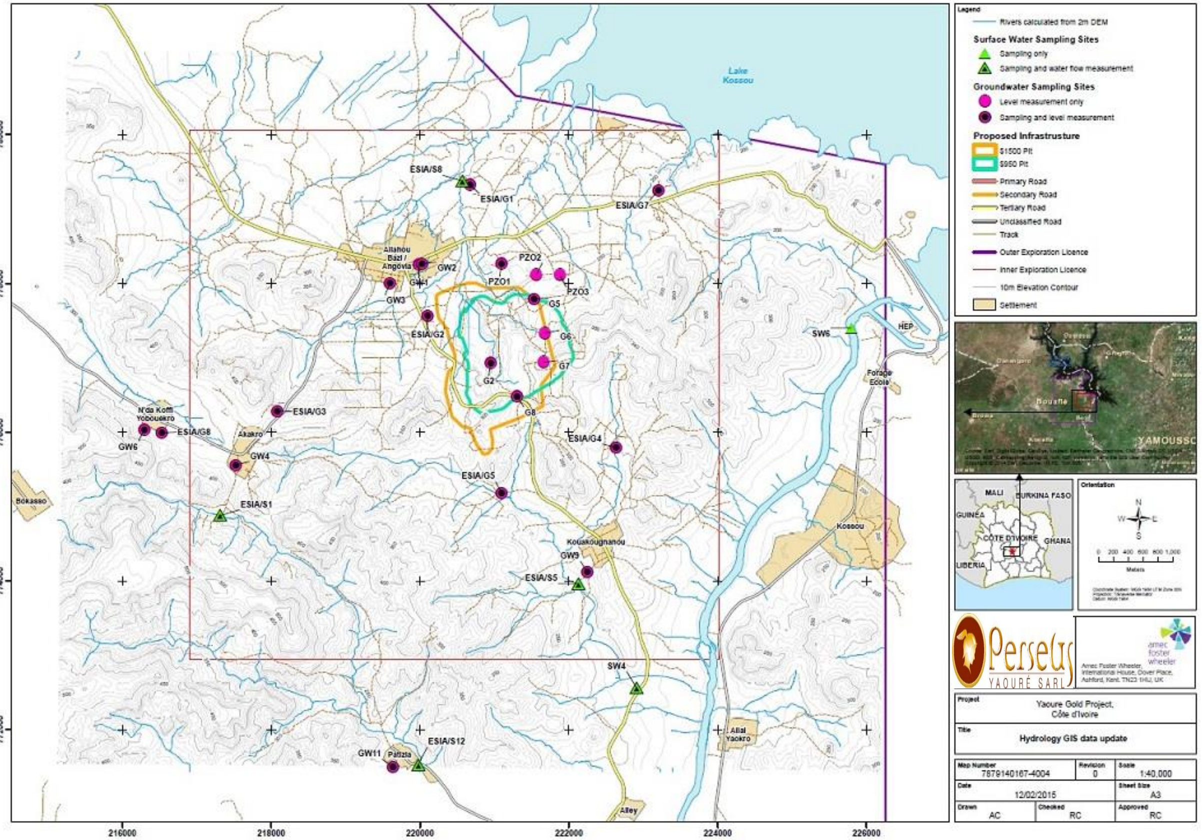


Table 6-26 Monitoring and test bore summary details

Borehole ID		Survey (UTM)				Drilling							
						Dates Drilled							
Drilled ID	Perseus / Local name	Date	Easting (m)	Northing (m)	Ground Elevation (m)	Start	Complete	Method	Drill angle (degrees)	Azimuth (degrees)	Drill hole diameter (mm) **	Total Depth (mbgl)	Purpose
G1	YDD0223G	18/07/2014	220775	777333.1	216.147	11/07/2014	14/07/2014	DD	80	270	HQ to NQ at 56.7m bgl	301.8	None
G2-OB	YDD0216G	17/07/2014	220950	776934.6	248.336	05/07/2014	09/07/2014	DD	80	270	HQ to NQ at 17.4m bgl	380.15	C1 Observation well - Bedrock; & baseline monitoring
G3	YDD0242	08/08/2014	221202	777333.0	269.842	28/07/2014	04/08/2014	DD	80	270	HQ to NQ at 72.4m bgl	394.8	None
G4	YDD0263	13/08/2014	221349	776933.3	295.915	02/08/2014	10/08/2014	DD	80	270	HQ to NQ at 59.9m bgl	400.8	None
G5 -OB	YDD0349	24/09/2014	221531	777792.4	253.834	17/09/2014	22/09/2014	DD	80	82	HQ to NQ at 35.5m bgl	440	C2 Observation well - Bedrock; & baseline monitoring
G6	YDD0359	30/09/2014	221675	777333.4	273.219	22/09/2014	27/09/2014	DD	80	90	HQ to NQ at 92.5m bgl	388.9	None
G7-OB	YDD0360	02/10/2014	221660	776937.9	317.693	24/09/2014	29/09/2014	DD	80	270 tbc	HQ to NQ at 59.5m bgl	350.25	C3 Observation well - Bedrock; & baseline monitoring
G8	YDD0361	01/10/2014	221301	776484.8	276.623	22/09/2014	30/09/2014	DD	80	270 tbc	HQ to NQ at 77.4m bgl	300	Baseline monitoring
ESIA G1	YRC754	28/10/2014	220670	779326.0	202.649	20/10/2014		RC	90	N/A	tbc	41	Baseline monitoring
ESIA G2	YRC757	31/10/2014	220101	777559.1	236.151	23/10/2014		RC	90	N/A	tbc	40	Baseline monitoring
ESIA G3	YRC756	31/10/2014	218080	776279.7	362.593	22/10/2014		RC	90	N/A	140	80	Baseline monitoring
ESIA G4	YRC759	11/11/2014	222632	775795.2	246.314	24/10/2014		RC	90	N/A	140	40	Baseline monitoring
ESIA G5	YRC760	11/11/2014	221095	775180.3	230.036	24/10/2014		RC	90	N/A	140	21	Baseline monitoring
ESIA G6	YRC758	11/11/2014	222166	777021.3	362.210	23/10/2014		RC	90	N/A	140	80	Baseline monitoring
ESIA G7	YRC753	28/10/2014	223202	779248.5	217.600	21/10/2014		RC	90	N/A	tbc	58	Baseline monitoring
ESIA G8	YRC755	31/10/2014	216529	775989.4	348.386	22/10/2014		RC	90	N/A	140	83	Baseline monitoring
G2-PW	YRC761	17/11/2014	220951	776927.4	248.217		24/10/2014	RC	90	N/A	140	80	C1 Pumping well - Regolith
G2-PW	YRC762	17/11/2014	220947	776941.6	248.353		29/10/2014	RC	90	N/A	140	270	C1 Pumping well - Bedrock

G2-OW	YRC763	17/11/2014	220958	776934.3	248.356		29/10/2014	RC	90	N/A	140	80	C1 Observation well - Regolith
G5-PW	YRC764	17/11/2014	221538	777800.9	253.915		31/01/2014	RC	90	N/A	140	270	C2 Pumping well - Bedrock
G5-OB	YRC765	17/11/2014	221545	777794.4	254.061		01/11/2014	RC	90	N/A	140	71	C2 Observation well - Regolith
G5-PW	YRC766	17/11/2014	221539	777786.2	254.486		01/11/2014	RC	90	N/A	140	77	C2 Pumping well - Regolith
G7-PW	YRC767	17/11/2014	221652	776937.6	317.206		02/11/2014	RC	90	N/A	140	186	C3 Pumping well - Bedrock

6.3.3 Packer tests

Packer testing was carried out for the 'Gash' geotechnical drill holes, G5 to G8, as summarised in Table 6-23. The packer tests were carried out in selected intervals of the NQ portions of the borehole. Packer intervals and results are summarised in Table 6-24.

Table 6-23 Geotechnical borehole summary

Borehole IDs Gash / Perseus		Water Level*	Date	Comment
G1	YDD223G	4.71	5/12/14	Blocked at 26.1m
G2	YDD216G	30.12	24/10/14	
G3	YDD242G	1.61	5/12/14	Blocked at 30.82m
G4	YDD263G	14.78	04/11/14	Slight response
G5	YDD349G	26.48	04/11/14	Packer Test - flow
G6	YDD359G	36.17	04/11/14	Packer Test - flow
G7	YDD360G	77.86	04/11/14	Packer Test - no flow
G8	YDD361G	34.95	04/11/14	Packer Test - no flow

Table 6-24 Packer test intervals

Single / Double	Test Section (mbgl)	Hydraulic conductivity (m/s)
Single	400-440	2.9E-7
Single	260-440	1.2E-7
Double	260-263	6.6E-6
Double	146-149	4.9E-6
Double	143-146	1.6E-6
Double	107-110	No Flow
Single	248-389	No Flow
Single	200-389	No Flow
Single	173-389	No Flow
Single	170-389	No Flow
Single	71-389	5.2 E-6
Double	71-74	No Flow
Double	68-71	No Flow
Double	59-62	No Flow
Double	56-59	No Flow
Single	280-350	No Flow
Single	200-350	No Flow
Single	172-350	No Flow
Double	175-178	No Flow
Single	166-350	No Flow
Single	250-300	No Flow
Single	199-300	No Flow
Single	148-300	No Flow
Single	100-300	No Flow
Single	79-300	No Flow

6.3.4 Well installation and development

The environmental monitoring bores (ESIA G1 through ESIA G8) were drilled and installed by Perseus. The monitoring bores were installed with 53 mm internal diameter (ID) PVC with screened intervals (1mm aperture machine slotted) targeting the water table in the weathered strata and weathered/unweathered contact. Installation depths ranged from 20 m to 80 m below ground level (bgl). A sand pack was installed in the bore annulus and bentonite seal emplaced above the screened interval.

Pumping test wells (YRC761 through YRC767) were installed with 125mm ID PVC with screen intervals in the fractured bedrock or the weathered strata depending on the target. Corresponding observation wells were installed using 53 mm ID PVC screened at the same interval as the associated pumping test well. Sand pack and bentonite seals were not installed in the pumping test or observation wells.

Angled geotechnical drill holes were installed with 19 mm ID galvanised steel pipe with manual perforations cut to target fracture zones identified in the unweathered bedrock. A sand pack was installed in the bore annulus and bentonite seal emplaced above the perforated intervals where possible. Piezometers were installed in G1-G4 prior to arrival on site and G8 had been abandoned.

6.3.5 Falling head tests

A total of 20 falling head tests were carried out in installed geotechnical, environmental, and pumping test boreholes, although only four provided useable results due to low permeability or too rapid change in water level following introduction of the slug of water. Results of the falling head tests are presented in Table 6-25.

Table 6-25 Falling head test results

Well	Hydraulic Conductivity (m/s)
ESIAG2 - YRC757	5E-07
ESIAG3 - YRC756	3E-07
ESIAG7 - YRC753	1E-06
ESIAG8 - YRC755	2E-07

6.3.6 Pumping tests

Pumping tests were conducted at three locations proximal to the planned open pit area (site G2, G5 and G7). Pumping tests were conducted in the weathered and unweathered bedrock strata at sites G5 and G2. The unweathered bedrock was the target for testing at site G7.

Pumping tests were planned to comprise step-test, constant rate test, and recovery monitoring. Most testing was constrained however by excessive pumping drawdowns due to low yield conditions in the pumping boreholes. Table 6-26 summarises the pumping test borehole groupings and targets. Interpretation was carried out using Aquifer-32 analytical software. A summary of the step test results is provided in Table 6-27, and the constant rate test results in Table 6-28.

Table 6-26 Summary of pumping test configurations

Site	Well type	Well ID	Target	Depth
G5 (bedrock)	Pumping well	YRC764	Bedrock	270
	Observation well	YDD349	Bedrock	440
	Observation well	YRC766	Weathered strata	77
	Observation well	YRC765	Weathered strata	71
G5 (weathered strata)	Pumping well	YRC766	Weathered strata	77
	Observation well	YRC765	Weathered strata	71
	Observation well	YRC764	Bedrock	270
	Observation well	YDD349	Bedrock	440
G2 (bedrock)	Pumping well	YRC762	Bedrock	270
	Observation well	YDD216	Bedrock	380
	Observation well	YRC761	Weathered strata	80
	Observation well	YRC763	Weathered strata	80
G2 (weathered strata)	Pumping well	YRC761	Weathered strata	80
	Observation well	YRC763	Weathered strata	80
	Observation well	YRC762	Bedrock	270
	Observation well	YDD216	Bedrock	380
G7 (bedrock)	Pumping well	YRC767	Bedrock	186
	Observation well	YDD360	Bedrock	380

Table 6-27 Summary of step test results

Pumped Well	Observation Well	Transmissivity (m²/day)	r*r*S (m²)	Coefficient Turbulent Head Loss (sq d / m5)
YRC762 (G2)	YRC761	78	6.3E-01	1.88E-06
YRC762 (G2)	YRC763	21	3.3E-02	-4.51E-05
YRC762 (G2)	YRC762 (G2)	8.6	1.7E-07	-2.87E-04
YRC762 (G2)	YDD216	16	6.5E-03	-4.13E-05
YRC761	YRC761	0.4	1.0E-02	4.80E-03
YRC761	YRC762 (G2)	Insufficient response to evaluate hydraulic parameters		
YRC761	YRC763	Insufficient response to evaluate hydraulic parameters		
YRC761	YDD216	No response was identified in well		
YRC764 (G5)	YRC764 (G5)	6.4	6.4E-02	5.65E-05
YRC764 (G5)	YRC766	No response was identified in well		
YRC764 (G5)	YDD349	6.3	1.3E-01	5.27E-05
GW7 (F1)	GW7 (F1)	18	1.1E-02	1.07E-05
GW8 (F2)	GW8 (F2)	1.2	3.4E-02	4.89E-03

6.3.7 Water level monitoring

Groundwater levels were periodically recorded throughout the field programme and have continued in accordance with the environmental baseline monitoring plan.

Table 6-29 provides a summary of the groundwater elevations.

Table 6-28 Summary of constant rate test results

Pumped Well	Observation Well	Constant Rate Pumping					Recovery	
		Curve Fit	Pumping Rate (l/min)	Transmissivity (m^2/day)	Storage Coefficient Ratio	Curve Fit	Transmissivity (m^2/day)	Storage Coefficient Ratio
YRC762 (G2)	YDD216	Hantush and Jacob 1955 Leaky Aquifer	15	1.50	1.3E-04	Theis 1946 Recovery	0.14	1.4E+00
	YRC761	Hantush 1960 Leaky Aquifer with Storage	15	2.72	3.0E-04	Theis 1946 Recovery	26.71	2.6E-01
	YRC762 (G2)	Hantush and Jacob 1955 Leaky Aquifer	15	0.64	1.1E-02	Theis 1946 Recovery	1.25	3.6E+00
	YRC763	Cooper and Jacob 1946 Straight Line Method	15	1.52	9.6E-05	Theis 1946 Recovery	0.02	1.1E+00
YRC764 (G5)	YDD349	Hantush 1960 Leaky Aquifer with Storage	19.5	0.16	4.3E-06	Theis 1946 Recovery	0.20	1.6E+00
	YRC764 (G5)	Cooper and Jacob 1946 Straight Line Method	19.5	0.64	8.5E-02	Theis 1946 Recovery	0.53	1.3E+00
	YRC765	Hantush 1960 Leaky Aquifer with Storage	19.5	2.82	1.2E-03	Theis 1946 Recovery	0.75	1.2E+00
	YRC766	Hantush 1960 Leaky Aquifer with Storage	19.5	4.40	2.3E-03	Theis 1946 Recovery	18.48	4.9E-02
YRC767 (G7)	YDD360	No measurable drawdown from pumping.						
	YRC767 (G7)	Well kept going dry. Insufficient data points. Pump rate not recorded						
GW7 (F1)	GW7 (F1)	Hantush 1960 Leaky Aquifer with Storage	5	24.074	0.457078	Theis 1946 Recovery	8.28	1.9E+01
GW8 (F2)	GW8 (F2)	Hantush 1960 Leaky Aquifer with Storage	0.56	1.31899	0.0250913	Theis 1946 Recovery	0.53	1.8E+01

Table 6-29 Groundwater level monitoring

Bore ID	Amara drill hole ID / local	Easting	Northing	Target	Ground Elevation	Stick-up	24/10/14	25/10/14	27/10/14	29/10/14	3/11/14	4/11/14	27/11/14	3/12/14	4/12/14	5/12/14	6/12/14	7/12/14	18/1/15	19/1/15	23/1/15	27/1/15	28/1/15	16/2/15	17/2/15	18/2/15	16/3/15	17/3/15	20/3/15
G1	YDD0223G	220775	777333	Bedrock	216.15	0.80					211.97					212.24													
G2-OB	YDD0216G	220950	776935	Bedrock	248.34	0.50	218.72									218.82			218.2						217.67		217.66		
G3	YDD0242	221202	777333	Bedrock	269.84	0.80					269.37					269.03													
G4	YDD0263	221349	776933	Bedrock	295.92	0.70	276.82				282.32	281.84				283.05													
G5 -OB	YDD0349	221531	777792	Bedrock	253.83	0.40	227.53			228.21	227.69	227.75	227.75									227.56			227.51		227.41		
G6	YDD0359	221675	777333	Bedrock	273.22	0.50					237.62	237.55			236.82							235.69			235.41				235.77
G7-OB	YDD0360	221660	776938	Bedrock	317.69	0.50				239.09	240.23	240.33			240.56						241.2				241.4				241.37
G8	YDD0361	221301	776485	Bedrock	276.62	0.50					252.31	242.17				240.74						241.22			241.12				241.47
G2-PW	YRC761	220951	776927	Regolith	248.22	0.40										217.497			217.107						217.357		217.347		
G2-PW	YRC762	220947	776942	Bedrock	248.35																								
G2-OW	YRC763	220958	776934	Regolith	248.36																								
G5-PW	YRC764	221538	777801	Bedrock	253.92	0.90																							
G5-OB	YRC765	221545	777794	Regolith	254.06	0.80																							
G5-PW	YRC766	221539	777786	Regolith	254.49	0.50											228.786					228.566			228.526		228.406		
G7-PW	YRC767	221652	776938	Bedrock	317.21										241.666						243.476				240.496				243.596
ESIA G1	YRC754	220670	779330	Regolith	202.65	0.80			197.3					198.62							197.45				197.04			196.69	
ESIA G2	YRC757	220101	777559	Regolith	236.15	0.80			226.18						226.51						224.93				223.95		223.36		
ESIA G3	YRC756	218080	776280	Regolith	362.59	0.90		303.41								303.54					303.66			303.71				303.68	
ESIA G4	YRC759	222632	775795	Regolith	246.31	0.90		237.76									238.45			238.16					238.01		237.86		
ESIA G5	YRC760	221095	775180	Regolith	230.00	0.80		228.72									228.94			227.25					226.61		226.37		
ESIA G6	YRC758	222166	777021	Regolith	362.21	0.90																							
ESIA G7	YRC753	223202	779249	Regolith	217.60	0.90		208.01								207.3							206.2		206.63			206.34	
ESIA G8	YRC755	216529	775989	Regolith	348.39	0.95		315.57										316.17			316.56			316.54				316.45	
PZ01	Piezometer 1	221096	778268											-21.52								-21.71			-21.74		-21.81		
PZ02	Piezometer 2													-16.55								-16.55			-16.52		-16.56		
PZ03	Piezometer 3													-7.05								-7.7			-7.98		-8.22		
GW1	Electric Pump	219982	778257																										
GW2	Allahou-Bazi well	220025	778263																										
GW3	Angovia well	219593	778005												-8.87														
GW4	Akakro well	217521	775559																										
GW6	N'da Koffi Yobouerkro well	216295	776036																										
GW9	Kouakougnanou well	222246	774119																										
GW11	Patizia well	219636	771500																										

6.3.8 Groundwater Water Quality Baseline

A total of 70 groundwater samples and 22 surface water samples have been collected to the cut-off date for measurement of field parameters and laboratory analysis in four campaigns during December 2014, January 2015, February 2015 and March 2015. The samples were obtained from 27 different installed surface and groundwater monitoring sites within the Yaoure Project area. Results are contained within Appendix 6, Surface Water Baseline (see also Figure 6-9, Table 6-30 and Table 6-31). The programme is ongoing.

Water samples were taken according to the Water Baseline Field Instructions sampling procedure and schedule. Field parameters, including pH, electrical conductivity (EC), dissolved oxygen (DO) and temperature were measured at the same time as sampling. Water samples for laboratory analysis were either directly taken from surface water courses or removed by pumping or bailing from monitoring wells. For monitoring well sampling at least three times the borehole volume was discharged before sampling. Rest water levels were measured before sampling.

Sample bottles were provided by the laboratory and contained preservatives as necessary. Samples were taken for both Total Metal and Dissolved Metal analysis. Samples for dissolved metals analysis were filtered using disposable 45 µm cellulose filters prior to putting in the sample bottles. Quality assurance (QA) and quality control (QC) includes the use of blank and duplicate samples.

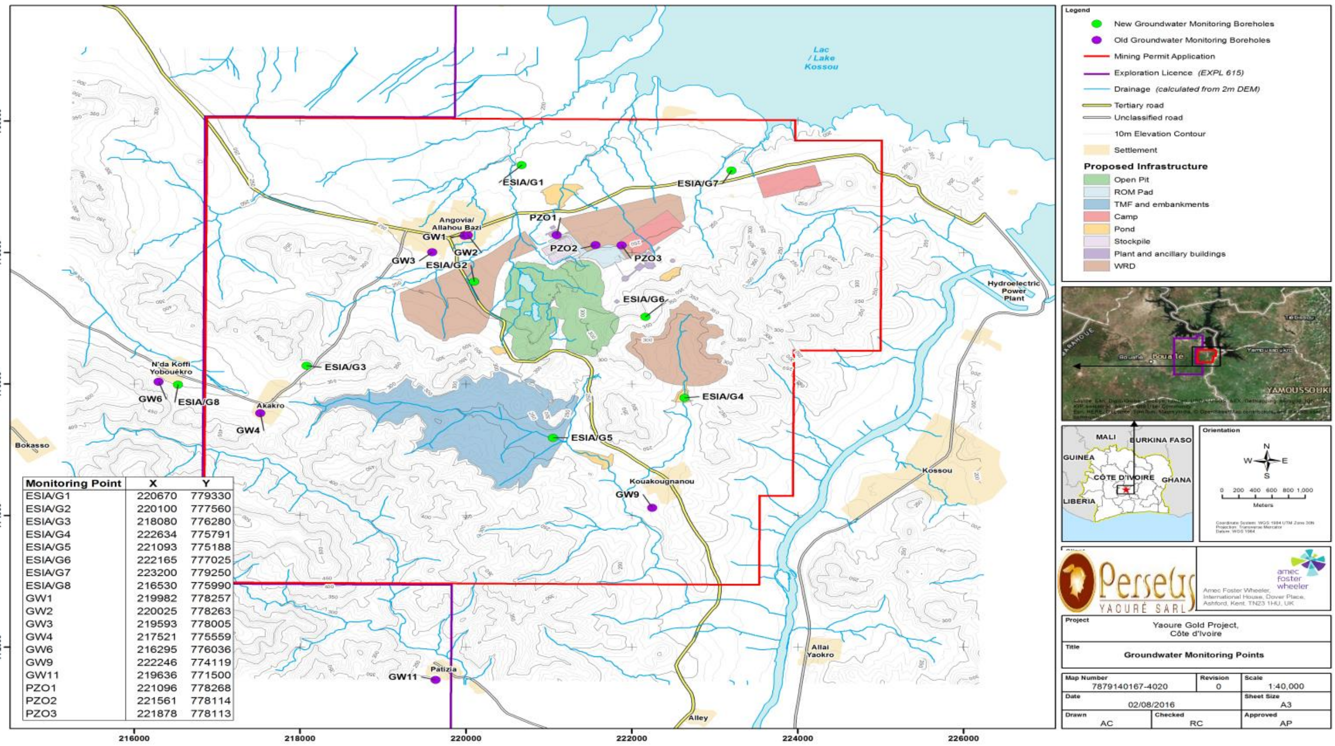
Table 6-30 Groundwater monitoring sites

Monitoring site	Easting	Northing
ESIA/G1	220670.4	779326
ESIA/G2	220101.4	777559.1
ESIA/G3	218080.2	776279.7
ESIA/G4	222632.2	775795.2
ESIA/G5	221094.5	775180.3
ESIA/G7	223201.6	779248.5
ESIA/G8	216529.3	775989.4
GW/1	219982	778257
GW/2	220025	778263
GW/3B	219593	778005
GW/4	217521	775559
GW/6	220769	778039
GW/9	222246	774119
GW/K	226240	774857
PZ01	221096	778268
PZ03	221878	778113
YRC 761	220950	776928
YRC 766	221524	777793

Table 6-31 Surface monitoring sites

Monitoring site	Easting	Northing
ESIA/S1	217312	774878
ESIA/S12	219976	771533
ESIA/S5	222128	773965
ESIA/S8	220568	779374
SW/4	222909	772564
SW/6	225794	777398
YSP	220834	777088
YCP	220583	777209
YNP	220719	777535

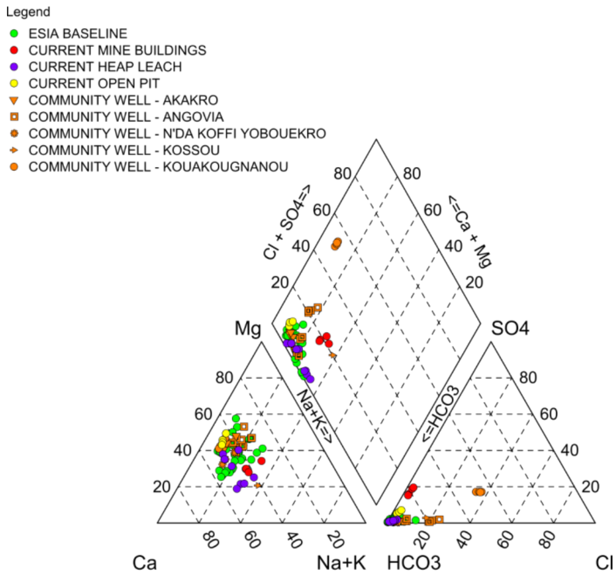
Figure 6-9 Historical and Recent Groundwater Monitoring Points



Monitoring Point	X	Y
ESIA/G1	220670	779330
ESIA/G2	220100	777560
ESIA/G3	218080	776280
ESIA/G4	222634	775791
ESIA/G5	221093	775188
ESIA/G6	222165	777025
ESIA/G7	223200	779250
ESIA/G8	216530	775990
GW1	219982	778257
GW2	220025	778263
GW3	219593	778005
GW4	217521	775559
GW6	216295	776036
GW9	222246	774119
GW11	219636	771500
PZO1	221096	778268
PZO2	221561	778114
PZO3	221878	778113

Plotting the major cations Na+, K+, Ca2+, Mg2+ and major anions HCO3-, CO32-, SO42- and Cl- on a trilinear Piper diagram assists in classifying the hydrochemical facies of groundwater and surface water samples. The majority of groundwater samples plot as Ca-Mg-HCO3 water type and the majority of surface water samples plot as Mg-Ca-HCO3 water type (Figure 6-10).

Figure 6-10 Piper Diagrams for groundwater and surface water samples



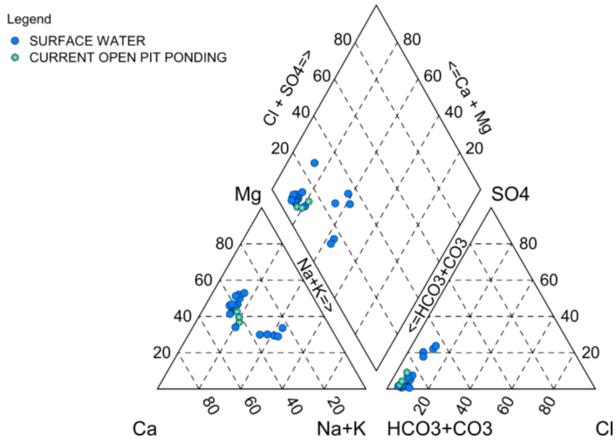


Table 6-32 Physical and chemical water characteristics

pH	The samples from Yaoure Project area have pH values from field measurements ranging from 6.68 to 8.38, with a mean value of 7.71
Electrical conductivity	Electrical conductivity values varied from 7.7 to 134.2 mS/m, averaging 43.2 mS/m.
Temperature	Field measurements from the December campaign show that the samples had temperatures ranging from 24.9°C to 28.6°C, with a mean value of 27.6°C.
Dissolved Oxygen	Field measurements only available from the December campaign show that the samples had dissolved oxygen values ranging 17.5 % to 113.9 %, with a mean value of 51.5 %.
Suspended solids at 103 -105°C	Total suspended solids at 103-105°C values for the sample vary from 1 to 10000 mg/L, averaging 191.8 mg/L.
Hardness	The calculated hardness values vary from 22 to 649 mg/L, with a mean value of 196 mg/L indicating very hard water. No health-based guideline value is proposed for hardness in drinking-water by WHO.
Turbidity	Turbidity for the samples ranges from 0.2 to 6900 NTU, with 61% of the samples giving values which exceed the World Health Organisation (WHO) Guideline Value for Drinking Water (2011) of 5 NTU.
Arsenic	Over two thirds of the samples had detectable measurements of dissolved arsenic. One sample from GW/6 has a dissolved arsenic value of 0.028 mg/L which marginally exceeds the WHO Guideline Value of 0.02 mg/L. The remaining samples have values averaging 0.0025 mg/L.
Antimony	Dissolved antimony measurements for samples range from 0.0001 to 0.004 mg/L which is below the WHO Guideline Value of 0.01 mg/L.
Cadmium	Only one sample from ESIA/S8 had a detectable level of dissolved cadmium. Measuring 0.002 mg/L it is below the WHO Guideline Value for Drinking Water of 0.003 mg/L.
Chromium	Just over half the samples had measurable levels of dissolved chromium. One sample from GW/4 has a dissolved chromium value of 0.079 mg/L which exceeds the WHO Guideline Value of 0.05 mg/L. The remaining samples have average of 0.0048 mg/L.
Copper	Dissolved copper exists at measurable levels in eleven samples, ranging from 0.001 to 0.0029 mg/L. These values are far below the WHO Guideline Value of 2 mg/L.
Lead	A third of the samples have measureable levels of dissolved lead. Three samples from ESIA/G4, ESIA/G7 and YRC 766 have dissolved lead values of 0.25, 0.02 mg/L and 0.014 mg/L respectively, which marginally exceed the WHO Guideline Value for Drinking Water of 0.01 mg/L. The remaining samples have an average of 0.0023 mg/L.

Mercury	Dissolved mercury was not detected in any of the samples.
Barium	Dissolved barium measurements for the samples range from 0.001 to 0.082 mg/L which is well below the Who Guideline Value of 0.7 mg/L.
Boron	Only nine samples had measurable levels of dissolved boron, with the largest value of 0.21 mg/L being well below the WHO Guideline Value of 2.4 mg/L.
Fluoride	Only six samples had measurable levels of dissolved fluoride, ranging from 0.1 to 0.4 mg/L. These values are well below the WHO Guideline Value of 1.5 mg/L.
Zinc	Almost half of the samples had detectable levels of dissolved zinc, ranging from 0.005 to 1.6 mg/L.
Selenium	Dissolved selenium was not at detectable levels in any of the samples.
Nickel	Dissolved nickel exists at measurable levels in over three quarters of the samples, ranging from 0.001 to 0.012 mg/L. These values are below the WHO Guideline Value of 0.07 mg/L.
Uranium	Dissolved uranium exists at measurable levels in twelve samples with values ranging from 0.001 to 0.002 mg/L which is well below the WHO Guideline Value of 0.03 mg/L.
Microbiology	No data was obtained on the microbial water quality.
Ammonia	Ammonia values for samples are all below 0.3 mg/L which has no direct relevance to health at these levels.
Nitrite	Nitrite exists at measurable levels in only eleven samples and these values are all below the Who Guideline Value for Drinking Water of 3 mg/L, averaging 0.26 mg/L.
Nitrate	Nitrate exists at measureable levels in almost two thirds of the samples. The four samples from borehole GW/9 have nitrate values between 220.3 and 348.4 mg/L which exceed the WHO Guideline Value for Drinking Water of 50 mg/L. The remaining samples have average Nitrate values of 4.6 mg/L.
Phosphate	Phosphate exists at measureable levels in just over half of the samples, but at low values ranging from 0.02 to 0.16 mg/L and averaging 0.07 mg/L.
Biochemical oxygen demand	Biochemical oxygen demand exists at measurable levels in over a quarter of the samples, ranging from 5 to 13 mg/L and averaging 7.6 mg/L.
Chemical oxygen demand	Chemical oxygen demand exists at measureable levels in a third of samples, ranging from 25 to 260 mg/L and averaging 48 mg/L/.
Phenol	Phenol was at measureable levels in only three samples ranging from 0.1 to 0.4 mg/L.

6.3.8.1 *Historical Groundwater Sampling*

Historical groundwater quality data is available for a range of dates between 2006 and 2013 for various locations, detailed in Table 6-. The locations of these and the recent groundwater monitoring points are shown in 0.

Table 6-37: Historical Groundwater monitoring locations

Location	Description	GPS Coordinates (UTM)	
		North	East
GW1	ALLAHOU BAZI Château	778257	219982
GW2	ALLAHOU BAZI Borehole	778263	220025
GW3	ANGOVIA Borehole	778005	219593
GW4	AKAKRO borehole	775559	217521
GW5	KOUAKOUGNANOU borehole		
GW6	FORAGE 1	776036	216295
GW7	FORAGE 2		
GW8	FORAGE 3		
GW10	Eaux de carrière		
GWA1	Fontaine Administration bloc		
GWC	Forage Camp BANLAW		
GWE	Fontaine ECOTEL		
GWK	Fontaine Kossou		
PZO1	Piézomètre 1	778268	221096
PZO2	Piézomètre 2	778114	221561
PZO3	Piézomètre 3	778113	221878
PZO4	Piézomètre 4		
PZO5	Piézomètre 5		

A statistical summary of the historical groundwater quality results is provided in Table 6-. Results exceeding the WHO limits for drinking water are written in red text. Bacteriological results are presented in Table 6-39.

The reliability of the groundwater quality data will have to be improved through the implementation of a regular monitoring programme. For some monitoring points very limited data was available. As with the surface water monitoring it is advised that the groundwater monitoring programme, initiated as part of the ESIA process, continues so as to ensure that sufficient reliable baseline data is available to compare against the operational phase monitoring data.

Table 6-38 Statistical Summary of Historical Groundwater Quality Results taken between 2006 - 2013

Location	Date / Statistical Parameter	pH	Turbidity (NTU)	Conductivity (µS)	Suspended matter (mg/L)	Dissolved solids	Ca (mg/L)	Mg (mg/L)	Na+ (mg/L)	K+ (mg/L)	Dissolved oxygen	PO_4 (mg/L)	NO_3 (mg/l N)	SO_4 (mg/L)	Mn Total (mg/L)	NO_2 (mg/L N)	Cl- (mg/L)
WHO 2011 Potable Water Guideline Limits			5						50				50				
GW1	MIN	6.38	<0.01	36.8		239	23	0.5868	13	0.37	3		0.000732	0.2	<0.01		0.55
GW1	MEAN	6.86	<0.58	201		245	33.3	26.3	21.3	0.791	3.7		2.32	2.57	<0.0372		6.67
GW1	MAX	7.24	1.19	554		257	48.096	77.445	29	1.1	4.4		6.46	4.8	0.075		18.02
GW1	COUNT	5	5	5	0	3	5	5	5	5	3	0	5	5	5	0	5
GW2	MIN	6.45	<0.01	492	<1		30.8	20.5	4.7	1.1		0.002473	0.000592	<0.1	0.088	0.0000525	11.64
GW2	MEAN	6.65	<7.67	635	<1		40.5	73.4	14.5	4.84		<0.105	1.25	<1.05	0.147	0.000976	30.64
GW2	MAX	6.99	22.8	778	<1		48.269	106.871	19.7	12.3		0.2933	3.63	2	0.206	0.0019	49.63
GW2	COUNT	3	3	2	1	0	3	3	3	3	0	3	3	2	2	2	2
GW3	MIN	6.7	<0.01	39	<1	200	23	19	8.8	0.085	3	<0.02	0.000372	<0.1	<0.001	0.000045	0.45
GW3	MEAN	7.06	<9.75	314	<1	255	39.9	49.3	21.7	0.402	3.4	<0.226	<0.432	<5.8	<0.08	0.00222	9.70
GW3	MAX	7.4	60	568	<1	315	53.7072	100.207	39	1.265	3.9	0.431	1.67	21.3	0.21	0.0044	19.02
GW3	COUNT	8	8	7	1	3	8	8	8	8	3	2	8	7	7	2	7
GW4	MIN	6.75	0.01	29.3	<1	179	21.1	12.5	5.6	0.147	2.5	<0.02	0.000392	<0.1	<0.001	0.000675	0.3
GW4	MEAN	7.18	0.659	247	<1	248	40.6	43.6	8.01	0.428	3.33	<0.22	11.6	<0.88	<0.0327	0.00169	5.35
GW4	MAX	7.75	1.7	482	<1	292	79.5	100.6104	10.7	0.965	4.4	0.42	53.6	2	0.146	0.0027	16.02
GW4	COUNT	8	8	7	1	3	8	8	8	8	3	2	8	5	7	2	7
GW5	MIN	6.56	<0.01	103.4	<1	620	62	47.5	23.4	0.167	2.2	<0.02	0.001732	41.24	1.027	0.014987	0.8
GW5	MEAN	6.89	<0.683	965	<1	647	110	140	30.1	0.45	3.25	<0.211	91.5	58.9	1.20	0.0255	50.7
GW5	MAX	7.56	1.8	1571	<1	674	136.6728	276.0024	35.875	1.065	4.3	0.402	276	89.08	1.547	0.036	107.37
GW5	COUNT	7	7	6	1	2	7	7	7	7	2	2	6	7	6	2	6
GW6	MIN	7	<0.01	345	<1		21.242	22.8	19.43	0.626		<0.02	0.000612	<0.1	0.149	0.00003	5.0055
GW6	MEAN	7.34	<6.31	592	<1		62.6	83.8	25.7	1.16		<0.257	0.0190	<14.4	0.322	0.000843	7.39
GW6	MAX	7.74	37.6	689	<1		84.5688	121.6098	35.18	1.6		0.494	0.07	35.8	0.529	0.0017	13.01
GW6	COUNT	6	6	5	1	0	6	6	6	6	0	2	6	5	5	3	5
GW7	MIN	6.6	<0.01	38.4		240	32.064	1.2632	13	0.586	4.3		0.00158	1.1	0.012		0.3
GW7	MEAN	6.61	<0.155	225.7		240	32.732	12.4316	20.25	0.793	4.3		<0.0308	3.965	<0.031		2.05
GW7	MAX	6.62	0.3	413		240	33.4	23.6	27.5	1	4.3		<0.06	6.83	<0.05		3.8
GW7	COUNT	2	2	2	0	1	2	2	2	2	1	0	2	2	2	0	2
GW8	MIN	6.6	<0.01	38.2		240	37	14.7	13	0.9	4.1		0.00099	4.2	<0.05		4.3
GW8	MEAN	7	<0.155	341		240	53.3	53.0	16.375	0.9805	4.1		<0.0305	6.375	<0.0985		4.65
GW8	MAX	7.4	0.3	644		240	69.6	91.35	19.75	1.061	4.1		<0.06	8.55	0.147		5.0055
GW8	COUNT	2	2	2	0	1	2	2	2	2	1	0	2	2	2	0	2
GW10	MIN	6.37	3	191.7	9		24.1	15.7	7.686	0.235		<0.02	0.000064	8	<0.001		0.6
GW10	MEAN	7.32	20.1	315	9		32.3	33.3	13.1	0.450		<0.02	0.0372	19.3	<0.0806		3.8
GW10	MAX	8	63.3	490	9		46.4928	57.2412	22.1	0.7		<0.02	0.11	27.32	0.216		7
GW10	COUNT	6	6	5	1	0	3	3	4	3	0	1	3	3	5	0	2
GWA1	MIN	7.2	<0.01	<1			50.5008	18.8	15.27	0.947		0.19	0.00072	<0.1	<0.001	0.0001925	5.0055
GWA1	MEAN	7.422	<0.088	<384			62.4	93.2	22.1	1.23		0.335	<0.0187	<13.0	<0.222	0.000546	7.86
GWA1	MAX	7.67	0.4	677			76.9536	130.8456	34	1.6		0.4806	<0.06	30.89	0.549	0.0009	11.18
GWA1	COUNT	5	5	5	0	0	5	5	5	5	0	2	5	4	4	2	4
GWC	12/10/2010	7.3	0.3	_	<1		31.3	17.5	35	1.8		0.06	1.07	4			
GWE	12/10/2010	7	<0.2	_	<1		56.6	20	34	1.6		0.18	0.06	10			
GWK	MIN	6.99	<0.01	117			9.218	17.823	3.65	0.628		0.223	0.000508	1	<0.001	0.0000275	3.0033
GWK	MEAN	7.26	<0.14	207			9.57	20.0	6.36	1.69		0.223	0.00627	7.64	<0.156	0.00361	4.424433333
GWK	MAX	7.43	0.22	352			10.274	21.7731	8.5	3.525		0.223	0.0163	11.07	0.404	0.0072	5.64
GWK	COUNT	3	3	3	0	0	3	3	3	3	0	1	3	3	3	2	3
PZO1	MIN	7.13	0.6	308	<1		35.1	10.6	17.33	0.956		0.04	0.00063	0	<0.001		1.0011
PZO1	MEAN	7.44	12.2	378	<1		42.0	38.2	25.7	1.18		0.04	0.355	0.5	<0.169		1.0011
PZO1	MAX	8.13	42	438	<1		48.8	65.8	32	1.4		0.04	0.71	1	0.436		1.0011
PZO1	COUNT	5	5	4	1	0	2	2	3	2	0	1	2	2	4	0	1
PZO2	MIN	7	1.1	479	<1		58.7	31.8	14.875	0.781		0.05	0.00066	2	<0.001		3.0033
PZO2	MEAN	7.33	5.13	662	<1		67.0	87.1	23.1	1.24		0.05	1.28	4.04	<0.327		3.0033
PZO2	MAX	7.7	10.5	755	<1		75.2	142.4	28	1.7		0.05	2.55	6.07	0.748		3.0033
PZO2	COUNT	5	5	4	1	0	2	2	3	2	0	1	2	2	4	0	1
PZO3	MIN	7.03	1.2	195.1	5		58.5	26.7	20.9	1.527		<0.02	0.00066	21.12	0.016		5.0055
PZO3	MEAN	7.24	17.2	535	5		62.1	72.0	30.5	1.56		<0.02	0.09033	27.1	0.0918		5.0055
PZO3	MAX	7.52	36.5	702	5		65.6	117.24	46	1.6		<0.02	0.18	33	0.289		5.0055
PZO3	COUNT	5	5	4	1	0	2	2	3	2	0	1	2	2	4	0	1
PZO4	MIN	7.07	13	215.1	96		19.3	3	21	4.2		0.12	3.9	28	0.076		
PZO4	MEAN	7.31	225	393	96		19.3	3	21	4.2		0.12	3.9	28	0.291		
PZO4	MAX	7.5	492	602	96		19.3	3	21	4.2		0.12	3.9	28	0.561		
PZO4	COUNT	5	4	3	1	0	1	1	1	1	0	1	1	1	3	0	0
PZO5	MIN	6.93	3.8	292	4		47.3	11.7	18	2.2		0.03	0.33	22	0.265		
PZO5	MEAN	7.18	58.4	292	4		47.3	11.7	18	2.2		0.03	0.33	22	0.265		
PZO5	MAX	7.32	113	292	4		47.3	11.7	18	2.2		0.03	0.33	22	0.265		
PZO5	COUNT	3	2	1	1	0	1	1	1	1	0	1	1	1	1	0	0

Location	Date / Statistical Parameter	Fe tot (mg/L)	Hardness (mg/L $CaCO_3$)	Cu tot (mg/L)	NH_4 (mg/L)	Ni tot (mg/L)	Pb (mg/L)	Zn (mg/L)	Hg (mg/L)	As (mg/L)	CO_3 (mg/L)	HCO_3 (mg/L)	CN- free (mg/L)	CN- tot (mg/L)
WHO 2011 Potable Water Guideline Limits				2		0.07	0.01		0.006	0.01				
GW1	MIN	<0.01	42		0.03				<0.001	0.002	10.5	87.84	<0.1	<0.1
GW1	MEAN	<0.0384	124		0.149				<0.00133	0.003	10.5	177.2133333	<0.1	<0.1
GW1	MAX	0.092	160.6		0.38				<0.002	0.004	10.5	244	<0.1	<0.1
GW1	COUNT	5	5	0	3	0	0	0	3	3	1	3	2	2
GW2	MIN	0.2	135	<0.02	<0.001	<0.001	0.272	0.056	<0.001	0.006	3	79.313	<0.003	<0.003
GW2	MEAN	0.288	151	<0.061	<0.0504	<0.0795	0.272	0.056	<0.001	<0.008	3	205	<0.0143	<0.0143
GW2	MAX	0.376	162	0.102	0.0998	0.158	0.272	0.056	<0.001	<0.01	3	326.35	<0.03	<0.03
GW2	COUNT	2	3	2	2	2	1	1	1	2	1	3	3	3
GW3	MIN	0.118	108	<0.02	<0.001	<0.001	0.394	0.096	<0.001	0.002	<2.5	122	<0.003	<0.003
GW3	MEAN	2.34	156	<0.031	<0.122	<0.0825	0.394	0.096	<0.00125	<0.0078	<2.75	261	<0.0486	<0.0486
GW3	MAX	7.18	195	0.042	0.26	0.164	0.394	0.096	<0.002	0.016	<3	364.78	<0.1	<0.1
GW3	COUNT	8	8	2	5	2	1	1	4	5	2	6	5	5
GW4	MIN	<0.01	86	0.02	<0.001	<0.001	0.149	0.008	<0.001	0.003	<2.5	78.08	<0.003	<0.003
GW4	MEAN	<0.201	129	0.08	<0.169	<0.11	0.149	0.208	<0.00125	<0.0096	<2.75	171.5571667	<0.0486	<0.0486
GW4	MAX	0.9	192.8	0.14	0.6968	0.219	0.149	0.407	<0.002	0.019	<3	254.37	<0.1	<0.1
GW4	COUNT	8	8	2	5	2	1	2	4	5	2	6	5	5
GW5	MIN	0.34	296.815	<0.01	<0.001	<0.001	0.202	0.024	<0.001	<0.002	<2.5	136.64	<0.003	<0.003
GW5	MEAN	1.38	403	<0.015	0.294	<0.0595	0.202	0.0635	<0.00133	<0.00575	<2.75	286	<0.0486	<0.0506
GW5	MAX	3.6	537	0.02	1.164	0.118	0.202	0.103	<0.002	0.01	<3	367.22	<0.1	<0.1
GW5	COUNT	7	7	2	5	2	1	2	3	4	2	6	5	5
GW6	MIN	<0.01	66.96	0.049	<0.001	<0.001	0.195	0.022	<0.001	<0.01	<3	138.104	<0.003	<0.003
GW6	MEAN	<0.27	174	0.112	<0.283	<0.0897	0.195	0.569	<0.001	<0.015	<3	320	<0.0455	<0.0455
GW6	MAX	0.88	256	0.245	0.8753	0.25	0.195	1.659	<0.001	0.02	<3	475.19	<0.1	<0.1
GW6	COUNT	4	6	4	5	3	1	3	1	2	1	6	6	6
GW7	MIN	0.048	51.77		0.036				<0.002	0.003	<2.5	104.92	<0.1	<0.1
GW7	MEAN	0.049	95.585		0.053				<0.002	0.003	<2.5	157	<0.1	<0.1
GW7	MAX	0.05	139.4		0.07				<0.002	0.003	<2.5	208.9	<0.1	<0.1
GW7	COUNT	2	2	0	2	0	0	0	1	1	1	2	1	1
GW8	MIN	0.08	153		0.24				<0.002	0.002	<2.5	216.6	<0.1	<0.1
GW8	MEAN	0.08	157		0.24				<0.002	0.002	<2.5	318	<0.1	<0.1
GW8	MAX	0.08	160.95		0.24				<0.002	0.002	<2.5	419.68	<0.1	<0.1
GW8	COUNT	1	2	0	1	0	0	0	1	1	1	2	1	1
GW10	MIN	0.076	83.694	<0.02	0.036	<0.001	0.026	0.006	0.001	<0.002	<3	122	<0.003	<0.003
GW10	MEAN	0.510	108	<0.0263	1.018	<0.0527	0.115	0.0377	0.001	<0.006	<3	143	<0.0583	<0.0486
GW10	MAX	2.109	125	0.031	2	0.149	0.203	0.075	0.001	<0.01	<3	158	<0.1	<0.1
GW10	COUNT	6	3	3	2	3	2	3	1	2	1	3	4	5
GWA1	MIN	0	173.518	<0.02	<0.001	<0.001	0.052	0.013	<0.001	<0.01	<3	123.464	<0.003	<0.003
GWA1	MEAN	<0.119	183	0.0543	<0.019	<0.0965	0.052	0.0645	<0.001	<0.01	<3	355	<0.0346	<0.0366
GWA1	MAX	0.366	208	0.111	0.054	0.192	0.052	0.116	<0.001	<0.01	<3	475.922	<0.1	<0.1
GWA1	COUNT	4	5	3	4	2	1	2	1	2	1	5	5	5
GWC	12/10/2010	<0.1	150	<0.02					<0.001	0.006	<3	246	<0.01	<0.01
GWE	12/10/2010	<0.1	224	0.03					<0.001	0.024	<3	338	<0.01	<0.01
GWK	MIN	<0.01	27.042	0.006	<0.001	<0.001	0.288	0.006		<0.01		15.4452	<0.003	<0.003
GWK	MEAN	<114	29.6	0.0235	<0.0107	<0.058	0.288	0.0373		<0.01		37.9	<0.0165	<0.0165
GWK	MAX	227	32.0471	0.041	0.03	0.115	0.288	0.091		<0.01		67.111	<0.03	<0.03
GWK	COUNT	2	3	2	3	2	1	3	0	1	0	3	2	2
PZO1	MIN	0.006	114.6	<0.02	0.18	<0.001	0.166	0.061	<0.001	0.004	<3	208	<0.003	<0.003
PZO1	MEAN	0.176	123	<0.02	0.18	<0.0725	0.166	0.135	<0.001	<0.007	<3	248	<0.0346	<0.0346
PZO1	MAX	0.4	131	<0.02	0.18	0.144	0.166	0.2	<0.001	<0.01	<3	287.92	<0.1	<0.1
PZO1	COUNT	5	2	2	1	2	1	3	1	2	1	2	5	5
PZO2	MIN	0.111	217.6	<0.01	0.18	<0.001	0.02	0.104	0.001	0.004	3	358	<0.003	0.01
PZO2	MEAN	0.554	247	<0.0207	0.18	<0.0683	0.082	0.124	0.001	<0.007	3	428	<0.0346	<0.036
PZO2	MAX	1.015	277	0.032	0.18	0.185	0.144	0.153	0.001	<0.01	3	497.76	<0.1	<0.1
PZO2	COUNT	5	2	3	1	3	2	3	1	2	1	2	5	5
PZO3	MIN	0.099	182.84	<0.002	0.18	<0.001	<0.01	0.119	<0.001	<0.01	3	44.08	<0.003	<0.01
PZO3	MEAN	0.323	219	<0.0107	0.18	<0.0975	<0.0175	0.128	<0.001	<0.015	3	195	<0.0346	<0.036
PZO3	MAX	0.7	256	<0.02	0.18	0.194	0.025	0.141	<0.001	0.024	3	346	<0.1	<0.1
PZO3	COUNT	5	2	3	1	2	2	3	1	3	1	2	5	5
PZO4	MIN	0.053	61	<0.02		0.173	0.025	0.011	<0.001	0.022	<3	98	<0.01	<0.02
PZO4	MEAN	3.05	61	<0.02		0.173	0.025	0.13	<0.001	0.022	<3	98	<0.04	<0.042
PZO4	MAX	10.508	61	<0.02		0.173	0.025	0.249	<0.001	0.022	<3	98	<0.1	<0.1
PZO4	COUNT	4	1	1	0	1	1	2	1	1	1	1	5	5
PZO5	MIN	0.2	166	<0.02		0.265		0.051	<0.001	0.002	<3	206	<0.01	0.02
PZO5	MEAN	0.27	166	<0.02		0.265		0.051	<0.001	0.002	<3	206	<0.0233	<0.0267
PZO5	MAX	0.34	166	<0.02		0.265		0.051	<0.001	0.002	<3	206	<0.03	<0.03
PZO5	COUNT	2	1	1	0	1	0	1	1	1	1	1	3	3

Table 6-39 Historical Bacteriological Groundwater Monitoring Results

Location	Date	E. Coli (UFC/mL)	F. Coliforms (UFC/mL)	Salmonella (UFC/mL)	Total Coliforms (UFC/mL)	Staphylococus (UFC/mL)	Streptocoques Fécaux (UFC/mL)
GW1	16/10/2006	NA	<2	NA	<2		
GW1	08/11/2006	NA	<2	NA	<2		
GW1	22/09/2008	Absent	<1	Present	43		
GW1	26/05/2009	Absent		Absent	Absent	1220	0
GW1	12/12/2009	0		Absent		0	0
GW2	12/10/2010	Absent		Absent	<1		
GW2	17/08/2011	<1		Present	<1	<1	<1
GW3	16/10/2006	NA	<2	NA	<2		
GW3	08/11/2006	NA	<2	NA	<2		
GW3	22/09/2008	Absent	<1	Present	3		
GW3	26/05/2009	Absent		Absent	Absent	0	0
GW3	12/12/2009	0		Absent		0	0
GW3	12/10/2010	Absent		Absent	<1		
GW3	17/08/2011	<1		Absent	<1	<1	<1
GW4	16/10/2006	NA	<2	NA	<2		
GW4	08/11/2006	NA	<2	NA	<2		
GW4	22/09/2008	Absent	<1	Present	4		
GW4	28/05/2009	Absent		Absent	Absent	303.10^3	0
GW4	12/12/2009	0		Absent		550	0
GW4	11/10/2010	Absent		Absent	<1		
GW4	17/08/2011	<1		Absent	<1	<1	<1
GW5	08/11/2006	NA	4	NA	<2		
GW5	22/09/2008	Absent	<1	Present	23		
GW5	28/05/2009	Absent		Absent	Absent	15.10^2	0
GW5	19/12/2009	0		Absent		1000	0
GW5	12/10/2010	Absent		Absent	<1		
GW5	17/08/2011	<1		Absent	<1	<1	<1
GW6	12/12/2009	0		Absent		0	0
GW6	06/03/2010	0		Absent	0	0	0
GW6	12/10/2010	Absent		Absent	<1		
GW6	17/08/2011	<1		Absent	<1	<1	<1
GW6	23/05/2012	<1		Absent	<1	<1	<1
GW7	16/10/2006	Absent	<1	Present	2		
GW7	28/05/2009	Absent		Present	158.10^2	0	0
GW8	16/10/2006	Absent	<1	Present	<1		
GW8	06/03/2010	0		Absent	0	0	0
GWA1	06/03/2010	0		Absent	0	0	0
GWA1	12/10/2010	Absent		Absent	<1		
GWA1	17/08/2011	<1		Present	<1	<1	<1
GWA1	23/05/2012	<1		Absent	<1	<1	<1
GWC	12/10/2010	Absent		Absent	4		
GWE	12/10/2010	Absent		Absent	<1		
GWK	17/08/2011	<1		Absent	<1	<1	<1
GWK	23/05/2012	<1		Absent	<1	<1	<1
PZ1	06/03/2010						
PZ2	06/03/2010						
PZ3	06/03/2010						
PZ4	10/04/2010						

6.3.8.2 Recent Groundwater Sampling

A total of 70 groundwater samples had been collected at the time of compiling the ESIA report for measurement of field parameters and laboratory analysis in four campaigns during December 2014, January 2015, February 2015 and March 2015. The samples were obtained from 18 different installed groundwater monitoring sites within the Yaouré Project area. The sampling points are included in Table 6- and **Error! Reference source not found.**. A statistical summary of the data is included in Table 6-. This summary takes consideration of the average values across all sampling locations for the four months for which data was available at the time the ESIA was written. Subsequently a full 12-month cycle of sampling and analysis has been completed.

Table 6-40 Recent Groundwater Monitoring Site Locations

Monitoring site	Easting	Northing
ESIA/G1	220670.4	779326
ESIA/G2	220101.4	777559.1
ESIA/G3	218080.2	776279.7
ESIA/G4	222632.2	775795.2
ESIA/G5	221094.5	775180.3
ESIA/G7	223201.6	779248.5
ESIA/G8	216529.3	775989.4
GW/1	219982	778257
GW/2	220025	778263
GW/3B	219593	778005
GW/4	217521	775559
GW/6	220769	778039
GW/9	222246	774119
GW/K	226240	774857
PZ01	221096	778268
PZ03	221878	778113
YRC 761	220950	776928
YRC 766	221524	777793

Table 6-41 ESIA Groundwater Monitoring Results 2014 - 2015

Parameter	Units	MIN	MEAN	MAX	COUNT	WHO Guideline
Lab pH		6	7.11	8.3	67	NGV
Turbidity	NTU	<0.2	<148	6900	67	5
Conductivity	mS/m	11.3	48.6	134.2	34	NGV
Total Suspended Solids at 103-105'C	mg/L	<1	<209	10000	67	NGV
Carbonate Alkalinity as CO3	mg/L	<1	<1	1	67	NGV
Total Alkalinity as CaCO3	mg/L	31	207	433	67	NGV
Bicarbonate Alkalinity as HC03	mg/L	37	253	528	67	NGV
Hardness by Calculation	mg/L	28	218	649	67	NGV
Calcium dissolved	mg/L	6	43.6	138	67	NGV
Chloride	mg/L	<0.1	<13.1	128	67	NGV
Fluoride by ISE	mg/L	<0.1	<0.124	0.4	33	1.5
Magnesium dissolved	mg/L	2.1	23.3	72	67	NGV
Potassium dissolved	mg/L	0.1	0.734	3.4	67	NGV
Sodium dissolved	mg/L	4.3	18.6	46.5	67	50
Sulphate	mg/L	<1	<10.2	80	67	NGV
Total Cyanide	mg/L	<0.005	<0.005	<0.005	17	NGV
Free Cyanide	mg/L	<0.005	<0.005	<0.005	1	NGV
Weak Acid Dissociable Cyanide	mg/L	<0.005	<0.005	<0.005	1	NGV
Ammonia as N	mg/L	<0.02	<0.0908	0.24	51	NGV
Ammonium as NH4	mg/L	<0.1	<0.124	0.3	34	NGV

Parameter	Units	MIN	MEAN	MAX	COUNT	WHO Guideline
Nitrate	mg/L	<0.06	<20.5	348.38	67	50
Nitrite	mg/L	<0.05	<0.0848	0.86	67	3
Phosphate	mg/L	<0.02	<0.0530	0.16	33	NGV
Phosphorus dissolved	mg/L	<0.05	<0.0581	0.09	16	NGV
Phenol	mg/L	<0.1	<0.118	0.4	33	NGV
Biochemical Oxygen Demand (BOD5)	mg/L	<5	<6.24	13	67	NGV
Chemical Oxygen Demand	mg/L	<25	<40.5	260	67	NGV
Aluminium dissolved	mg/L	<0.03	<0.0301	0.04	67	NGV
Antimony dissolved	mg/L	<0.0001	<0.000419	0.004	16	0.02
Arsenic dissolved	mg/L	<0.0005	<0.00248	0.013	66	0.01
Barium dissolved	mg/L	<0.001	<0.0171	0.082	67	0.7
Beryllium dissolved	mg/L	<0.0005	<0.0005	<0.0005	16	NGV
Bismuth dissolved	mg/L	<0.1	<0.1	<0.1	16	NGV
Boron dissolved	mg/L	<0.02	<0.0351	0.21	67	2.4
Cadmium dissolved	mg/L	<0.0001	<0.0001	0.0001	67	0.003
Chromium dissolved	mg/L	<0.001	<0.00557	0.079	67	0.05
Chromium-6	mg/L	<0.04	<0.04	<0.04	67	0.05
Cobalt dissolved	mg/L	<0.001	<0.00143	0.007	67	NGV
Copper dissolved	mg/L	<0.001	<0.00149	0.013	67	2
Iron dissolved	mg/L	<0.1	<0.148	0.6	50	NGV
Lead dissolved	mg/L	<0.0005	<0.00546	0.25	67	0.01
Lithium dissolved	mg/L	0.0006	0.0253	0.11	16	NGV
Manganese dissolved	mg/L	<0.002	<0.161	1.64	67	NGV
Mercury dissolved	mg/L	<0.0001	<0.0001	<0.0001	67	0.006
Molybdenum dissolved	mg/L	<0.0005	<0.00241	0.012	16	NGV
Nickel dissolved	mg/L	<0.001	<0.00397	0.012	67	0.07
Selenium dissolved	mg/L	<0.01	<0.01	<0.01	67	0.04
Silicon dissolved	mg/L	5.74	23.1	35.9	33	NGV
Silver dissolved	mg/L	<0.0001	<0.0001	<0.0001	16	NGV
Strontium dissolved	mg/L	0.022	0.166	0.537	67	NGV
Thallium dissolved	mg/L	<0.0001	<0.000131	0.0006	16	NGV
Tin dissolved	mg/L	<0.0002	<0.000238	0.0005	16	NGV
Titanium dissolved	mg/L	0.0018	0.00648	0.0095	16	NGV
Uranium dissolved	mg/L	<0.0001	<0.000356	0.002	16	0.03
Vanadium dissolved	mg/L	0.0017	0.00607	0.015	16	NGV
Zinc dissolved	mg/L	<0.005	<0.0719	1.6	67	NGV

6.3.8.3 Physical Characteristics of Yaouré Groundwater

The samples campaign from Yaouré Project undertaken as part of the ESIA have pH values from field measurements ranging from 6 – 8.3, with a mean value of 7.11, which is within the CIAPOL limits of 5.5 – 8.5. ESIA/G2 location had the most acidic waters with an average pH of 6.25.

Total Suspended Solids ranged between <1 and 10000 mg/l, with an average of <209 mg/l, with 8 samples exceeding the CIAPOL higher limit of 150 mg/l and 9 further samples exceeding the lower limit of 50 mg/l if the discharge load exceeds 15 kg/day.

Electrical conductivity values varied from 11.3 to 134.2 mS/m, averaging 48.6 mS/m.

The calculated hardness values vary from 28 – 649 mg/l, with a mean value of 218 mg/l.

6.3.8.4 Heavy Metals Characteristics of the Yaouré Groundwater

The following summarise heavy metals and other trace element results from the initial campaigns of the ESIA programme

Antimony
Dissolved antimony measurements for samples range from <0.0001 – 0.004 mg/l which is below the WHO (2010) Guideline Value of 0.01 mg/l.

Arsenic
Over 80% of the samples had detectable measurements of dissolved arsenic. One sample from GW/6 has a dissolved arsenic value of 0.028 mg/l, which marginally exceeds the WHO Guideline Value of 0.02 mg/l.

Cadmium
All cadmium values were equal or less than the limit of detection, 0.001mg/l, which is below the WHO Guideline Value for Drinking Water of 0.003 mg/l.

Chromium
One sample from GW/4 has a dissolved chromium value of 0.079 mg/l, which exceeds the WHO Guideline Value of 0.05 mg/l. The remaining samples have average of <0.00557 mg/l.

Copper
Dissolved copper ranges from <0.001 – 0.0013 mg/l. These values are far below the WHO Guideline Value of 2 mg/l and the CIAPOL limits of 0.5 mg/l if the discharge load exceeds 5 g/day.

Iron
Dissolved iron varied between <0.1 and 0.6mg/l. Total iron total ranged between 0.1 and 142 mg/l, with an average of 5.92 mg/l, with 6 samples exceeding the CIAPOL limit of 5 mg/l if the discharge load exceeds 20 g/day. As with the surface water quality, this can be attributed to the natural geology of the area.

Lead
Three samples from ESIA/G4, ESIA/G7 and YRC 766 have dissolved lead values of 0.25, 0.02 mg/l and 0.014 mg/l respectively, which marginally exceed the WHO Guideline Value for Drinking Water of 0.01 mg/l. The lead values were well below the CIAPOL limits of 0.5 mg/l if the discharge load exceeds 5 g/day.

Manganese
Manganese varied between <0.002 and 1.64 mg/l with an average of <0.161 mg/l. 4 samples exceeded the CIAPOL limit of 1 mg/l if the discharge load exceeds 10 g/day. This can be contributed to the natural geology.

Mercury
Dissolved mercury was not detected in any of the samples.

Nickel
Dissolved nickel concentrations range between <0.001 and 0.012 mg/l. These values are below the WHO Guideline Value of 0.07 mg/l and the CIAPOL limits of 0.5 mg/l if the discharge load exceeds 5 g/day.

Selenium
Dissolved selenium was not at detectable levels in any of the samples.

Uranium
Dissolved uranium exists at measurable levels in 9 of 16 samples with values ranging from <0.001 – 0.002 mg/l which is well below the WHO Guideline Value of 0.03 mg/l.

Zinc

Zinc concentrations range from 0.005 and 1.6 mg/l.

Barium
Dissolved barium measurements for the samples range from <0.001- 0.082 mg/l which is well below the Who Guideline Value of 0.7 mg/l.

Boron
The largest value of 0.21 mg/l boron is below the WHO Guideline Value of 2.4 mg/l.

Fluoride
Only six samples had measurable levels of dissolved fluoride, ranging from <0.1- 0.4 mg/l. These values are well below the WHO Guideline Value of 1.5 mg/l.

6.3.8.5 Nutrients and Organics Characteristics of Yaouré Groundwater

Ammonia
Ammonia values for samples are all below 0.3 mg/, which has no direct relevance to health at these levels.

Nitrite
Nitrite exists at measurable levels in only nine samples. Nitrite values are all below the WHO Guideline Value for Drinking Water of 3 mg/l with a maximum of 0.86 mg/l.

Nitrate
Nitrate exists at measureable levels in over 60% of the samples. The four samples from borehole GW/9 have nitrate values between 220.3 and 348.4 mg/l which exceed the WHO Guideline Value for Drinking Water of 50 mg/l NO_3. This is most likely a result of local village sewage disposal practices.

Phosphate
Phosphate exists at low values ranging from <0.02 – 0.16 mg/l.

Biochemical oxygen demand
Biochemical oxygen demand ranges between <5 to 13 mg/l.

Chemical oxygen demand
Chemical oxygen demand ranges between <25 – 260 mg/l.

Phenol
Phenol ranges between <0.1 and 0.4 mg/l.

6.4 Soil baseline

A soil and land capability assessment was carried out as part of the 2007 ESIA process for Cluff Gold. The results of the 2007 study, together with relevant climate, geology, geomorphology, soil wetness and terrain morphology information formed the basis for the 2015 soil and land capability study.

The 2015 soil and land capability study was designed as the basis for the confirmation, characterisation and classification of the different soil forms in the Project area and the rating of the capability of the land. The classification of the soils is based on a set of norms and specific principles set out in the "Taxonomic Soil Classification" (Mac Vicar et al., 1991), and the Canadian Land Inventory Systems that are compatible with international standards, and consistent with the requirements of the IFC PS, 2012. One of the more important outcomes of the soil characterisation and classification exercise was the delineation and characterisation of dominant soil forms and the rating of the soil sensitivity in terms of the activities being proposed.

6.4.1 Methodology

The methodology used for the study involved the following:

- A desktop assessment using the aerial imagery and a broad grid base to delineate and assimilate the baseline information. This information was then used as the basis for the site evaluation, verification and infill sampling programme;

- A soil survey, examining soil profiles, using a hand operated auger and any natural exposures (pits, road cuttings and areas exposed through artisanal mining) was undertaken based on the outcome of the desktop survey, The identification and classification of soil profiles were carried out using the Taxonomic Soil Classification System (Mac Vicar, 1991). The soil classification take consideration of:

    - Demarcation of master horizons;

    - Identify the horizons analysing the physical properties, including: depth, texture, structure, mottling, visible pores, concretion and compaction;

    - Identification of the appropriate soil form;

    - Indentification of soil capabilities;

- In addition representative soil samples (0.2 kg) were taken at areas not covered during the 2007 survey and submitted to an accredited laboratory for analysis (SGS Ghana). The soil samples were analysed for pH, exchangeable bases, cation exchange capacity, texture (% clay), nutrient status and contaminants. The laboratory analysis included: analysis for basic elements through a Spectro Atomic Analyser, determining the organic carbon contents through the titration method and determining clay content using a density meter; and

- Soil classification was carried out based on field observations regarding the nature, depth, erodibility and the laboratory results of the various soils.

Due to the extent of the proposed operations the soils in the study area were grouped into dominant categories that can be managed in a similar manner, rather than to distinguish the various soil types. Classification of dominant soil groups is useful where large quantities of soils have to be moved. The groupings of soil types comprise soils that have similar characteristics for which a set of impacts are common, and for which the similar management measures apply for any given activity.

Where the area of development is smaller and small pockets of soil can be managed it makes more sense to classify soils into soil types.

The objectives of the study were to identify and classify the area in terms of:

- The soil types (groups) to be disturbed/rehabilitated;
- The soil physical and chemical properties;
- The soil depth;
- The erodibility of the soils;
- Pre-construction soil utilisation potential, and
- The soil nutrient status.

The results of the soils and land capability baseline are discussed in terms of the "site sensitivity". The soil mapping has been simplified based on the dominant soil groups and their associated land capability.

6.4.2 Baseline Soil Findings

The historic activities associated in the Project area, including mining, artisanal mining, slash-and burn agriculture and subsistence farming have had a significant impact on ecosystem services, land capability, soil structures as a result of compaction and erosion, and the health of surface water resources where erosion contributed to significant silt loads.

6.4.2.1 Soil groups

Four major soil groups were identified on site. These forms are closely associated with the lithologies from which the soils are derived, the topography and general geomorphology of the site, the effects of topographic slope and attitude of the land forms which directly affects the pedogenetic processes of soil formation and ultimately the soil forms. The four major land groups are:

1. The deeper and more sandy loam soils: These soils are generally founded on a ferricrete gravel or thick saprolitic layer, located mainly in the south central and south western sectors of the study area (refer to Figure 6-6). This soil form is considered a *High Potential* material and is distinguished by the greater than average soil depth (100 cm to >150 cm) and better drainage within the soil profile (80 mm/m to 180 mm/m).

   This group is recognizable by the complete lack of, or very subtle, mottling, a fine to medium grained texture, apedel to weak crumby structure and clays that range from as low as 12% to 18% in the top soil, and between 20% and 28% in the subsoil. The land capability is rated as moderate intensity grazing land and/or moderate arable land capability depending on the nutrient and organic carbon stores and related production potential.

   These soils are generally slightly lower in clay than the associated wet based soils and more structured and colluvial derived materials and have a distinctly weaker structure. The more sandy texture of this soil group renders them more easily worked and of a relatively lower sensitivity (depth >75 cm).

2. Shallower and often slightly more structured soil group, comprising fine to medium grained sandy clay loams for the most part: This group (<500mm) of soils is associated almost exclusively with the sub-outcropping of the parent materials or shallow lithocutanic/saprolitic horizons. Therefore, the distribution of these materials appears to be lithologically controlled with predominance in the southern and south eastern sectors of the study area (refer to Figure 6-6). These soils are considered sensitive to moderately sensitive in terms of erosion, compaction and their workability and will require greater management if disturbed. This soil form has a relatively large and important function in the sustainability of the overall biodiversity.

   These soils are apedel to moderate blocky at the extreme, with clay contents that range from 18% in the upper horizons to as high as 35% where the soils are associated with a more basic geology (dolerite).

3. Soils associated with the hard pan ferricrete layer and perched/confined soil water: This soil group is associated with large areas of well-developed ferricrete outcrop/sheet outcrop and laterite is common within the vadose zone. In addition the development of wet based soils and moist grassland environments was also mapped in association with these soil forms. These soil groupings are moderately extensive in spatial area, and cover a significant proportion of the proposed development (both mining and its infrastructure).

   This group of soils has a set of distinctive characteristics and nature that are separated from the other soil groupings as it has inherently difficult management characteristics.

These soils are characterised by relatively significantly higher clay contents (18% to 25%) in the topsoil and as high as 60% in the subsoil - sometimes of a swelling nature – smectites), poor water intake rates, inhibited and poor drainage (60 mm/m to 100 mm/m) characteristics and the associated poor liberation of soil water to plants. This is particularly true in the case of the more platy and swelling clays which bind the soil water.

The more structured nature of these soils and the inherent wetness are restrictive on rooting depths, while the hard pan nature of the ferricrete is also an inhibiting factor and a barrier within the top 50 cm to 75 cm of the soil profile. These soils are generally associated with a wet or saturated basal horizon, and are considered to be sensitive to highly sensitive in nature, albeit that they are generally considered to be of a "relic" land form.

These soils will be more difficult to work in the wet state and more difficult to store and re-instate at closure. Additional management inputs and mitigation will be recommended for areas that rate as highly sensitive or valuable in terms of the soil and land capability.

4. Soils that reflect wetness within the top 50 cm: These soils were easily recognised by the mottled red and yellow colors on low chroma background to the soil. These soils are distributed in pockets across the site and are regarded as highly sensitive zones that will require management inputs if disturbed.

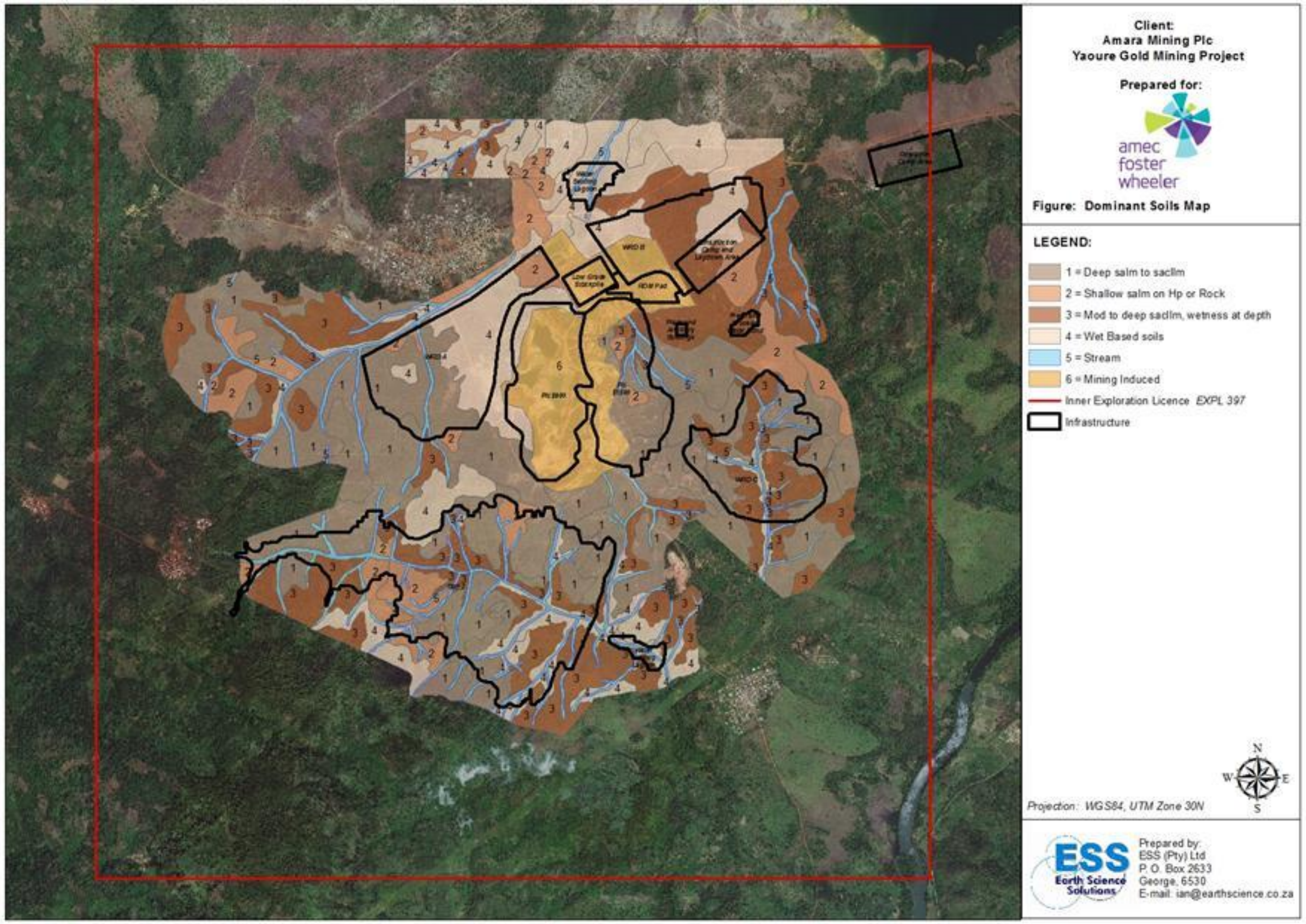
   The concentrations of natural salts and stores of nutrients within these soils are again a sensitive balance due to the extremes of rainfall (excessive leaching) and temperature, with leaching evident in the low chroma colours. The ability of a soil to retain moisture and nutrients, and in turn influence the sustainability of vegetative growth and dependence of animal life is determined by the consistency and degree of soil moisture retention within the profile but out of the influence of evaporation. The conditions and associated sensitivities should be noted in terms of the overall bio-diversity balance if the sustainability equation is to be managed and mitigation engineered.

   The wet based and very shallow soils are considered being of high sensitivity and are vulnerable to being disturbed or worked on. These soils will require added input and management if they are to be considered for development. The previous study undertaken in 2007 indicated a similar trend albeit that the study was more orientated towards better understanding the land capability potential and land use in the area of concern.

   Soil wetness and the presence of hydromorphic conditions (wetlands) are considered important characteristics and these environments are rated as sensitive to highly sensitive, and areas that need to be flagged as sites requiring special attention.

The four dominant soil forms are included in Figure 6-6.

Figure 6-61 Yaoure Gold Project: Dominant Soil Forms



6.4.2.2 *Soil sensitivity*

The depth to an inhibiting layer and the amount of redox reaction present (noted in the degree of mottling and more importantly the greyness of the soil matrix) within the profile and the degree of wetness in terms of the "wetland delineation classification" will have an effect on the ecological sensitivity of the site.

Soil group 1, the deeper and more sandy profiles, have distinct pedogenetic processes that are associated with lower clay contents, better drainage of the soils and a deeper weathering profile. The degree of iron formations is less, with the percentage of base metals considered the primary driver of soil metal contents. Iron rich/ferruginous gravels were noted at the base of many of these profiles.

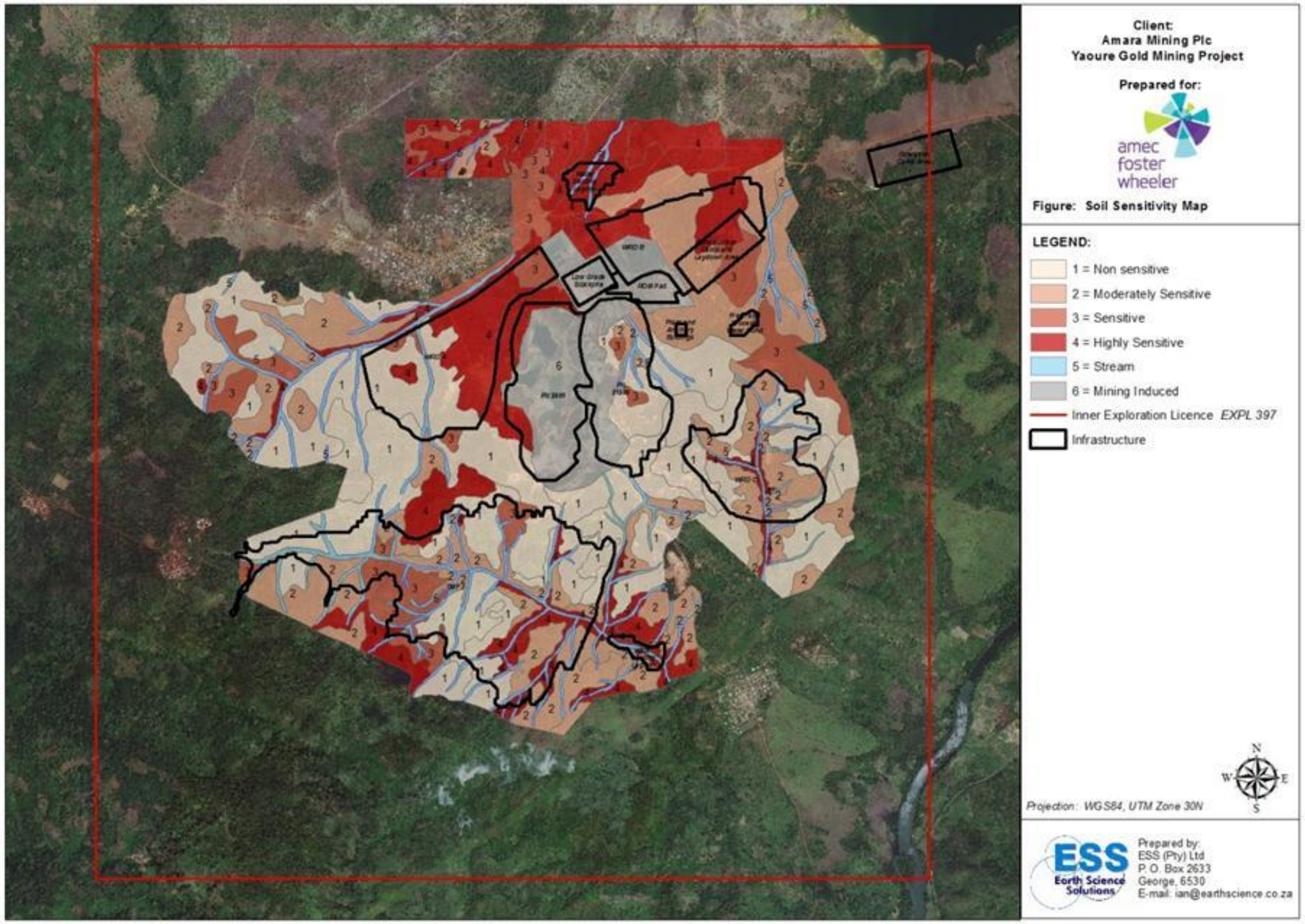
In soil group 2, the shallow to very shallow soil profiles are generally associated with an inhibiting layer at or close to the surface, and as already alluded to, is the defining feature that controls the ability (or lack of it) of water to flow vertically down and through the profile (restrictive layer).

In soil groups 3 and 4, the degree to which the plinthite layer has been cemented (friability of the ferricrete) will determine the effectiveness of the layer as a barrier to infiltration, while the depth of overlying soil will dictate how easily or difficult it is for the soil water to be accessed by the fauna and flora, and in the extreme case wether water is held at surface. The friability of the ferricrete will also have an effect on the amount of clay mineralisation that the soil contains within this horizon, and will in turn influence the water holding characteristics of the soil and the degree of structure of the material above the ferruginous layer.

As with any natural system, the transition from one system to another is often complex with multiple facets and variations over relatively small/short distances, something that is particularly pertinent to this particular area as the attitude of the lithological units is inclined at varying degrees of dip.

With these considerations and variables assessed, the relative sensitivity of the site was mapped. Figure 6-72 depicts the spatial distribution and relative sensitivities (insensitive, moderately sensitive, sensitive and highly sensitive) of the study area.

Figure 6-72 Yaoure Gold Project Soil Sensitivity



6.4.2.3 *Soil Chemical Characteristics*

The results of the laboratory analysis reveal the differences in the chemistry of the different geologies/lithologies from which the soils are derived and the influence of climate, soil movement and the leaching of the soil nutrients over time.

The analytical results reflect a variety of differing source materials that range from very well sorted sandy loams with lower than average nutrient stores and moderate clay percentages (12% to 18% - B2/1 horizon), to soils with a moderately stratified to moderate blocky (pedocutanic) structure, sandy loam to sandy clay loam texture and varying degrees of utilisable nutrients. These soils are generally confined to the colluvial derived materials with higher than average clays (+25%), and highly variable structure (weak blocky to prismacutanic and gleycutanic). These soils are confined almost exclusively to the wet based and wetland soils associated with the alluvial/colluvial derived and bottom land floodplain wetlands.

In general, the pH ranges from weakly acid at 5.1 to slightly more neutral at 6.5, base status ranging from 6.5 me% to 18 me% mesotrophic (moderate leaching status) to dystrophic (highly leached), and nutrient levels reflecting generally moderate to high levels of calcium and magnesium (acceptable Ca/Mg ratios 3:1), and moderate to good levels of sodium and potassium. The phosphate levels are generally high, with areas of very high and possibly toxic aluminium contents. The levels of iron and zinc are also high and evident in the sheet ferricrete. The metals were assessed as part of understanding the baseline values, and so that management of impacts can be gauged once the mining and processing starts.

The soil distribution and its associated chemistry is linked to a great extent to the geology from which it is derived, and as such, the changes occur over relatively small spatial distances due to the attitude of the lithological units. This makes for some difficulty in describing the effects of soil chemistry on the environment when using a reconnaissance grid base. However, there is sufficient information available for generalised patterns and conclusions to be drawn, and for the effects of the soil nutrients to be gauged against the possible impacts that will be imposed by the Project.

The relationship between geology and soil chemistry is not as strong in the lower lying areas and floodplains of the river systems where the soils are of a colluvial or alluvial origin, and the effects of having been transported over distance has masked any input of the geology. The chemical signature on these materials is far more variable, with the effects of leaching quite apparent.

Sites with elevated aluminum, zinc/iron and Phosphate are not generally conducive to the cultivation of cereals and vegetables. Cassava and the natural vegetation (indigenous bush) found in these tropical environments have adapted to the chemistry of these soils, but little of commercial value will grow naturally in these conditions.

Error! Reference source not found. provides the details of the soil chemical analyses at 11 sampling points, the locations of which are shown on the respective maps in **Error! Reference source not found.**.

6.4.2.4 Soil fertility and Nutrient Storage and Exchange Rate (CEC)

With regards to soil fertility, the soils in the Project are returned moderate levels of some of the essential nutrients required for plant growth with sufficient stores of sodium, potassium and phosphates (excessive), and adequate concentrations of calcium and magnesium. The levels of Al and P associated with some of the soils (generally associated with the more basic geologically derived materials) are considered restrictive to the growth of many plants, and as such, the potential for the cultivation of commercially viable food schemes is considered negative.

However, the deep sandy loams and most of the colluvial/alluvial derived soils associated with the larger streams and floodplain deposits (Tk, Tk/Pn, Pn, Oa and Gc) hold some potential for commercial agriculture, with better than average organic carbon and sufficient water holding capability on well drained materials. Therefore, the most viable agricultural soils are associated with soil group 3 (refer to Section 6.4.2.1 and Figure 6-6).

The potential of a soil to retain and supply nutrients were assessed through analyzing the cation exchange capacity (CEC) of the soils. Low CEC values are an indication of soils lacking organic matter and clay minerals. Typically a soil rich in humus will have a CEC of 300 me/100g (>30 me/%), while a soil low in organic matter and clay may have a CEC of 1-5 me/100g (<5 me/%).

Generally, the CEC values for the soils mapped in the area are moderate to good, with all but the alluvial (soil group 4) and deep colluvial materials (areas associated with soil group 1) returning adequate values for positive plant growth.

6.4.2.5 Soil Physical Characteristic

The majority of the soils mapped exhibit apedal to weak crumby structure, moderate to high clay content and a dystrophic leaching status. The texture comprises sandy loams or sandy clays and clay loams for the most part, with much finer silty loams and clay loams associated with the colluvial and alluvial derived materials mapped in the lower slope and bottom land stream and river environs.

Of significance to this study, and a feature that is common across large portions of the Project site is the deep weathering of the soils (up to 10m recorded in drill cores) that is a function of the geology and the high rainfall. However, this is contrasted by the very shallow and sheet form ferricrete "banks" noted on the more basic iron rich lithologies.

The presence of the laterite of ferricrete layers is associated with the more flat dipping iron and magnesium rich sedimentary host rocks (albeit that it often occurs below the 1.5 m auger depth on the deeper soils) and the climatic conditions, all conducive to the formation of evaporites. The tropical climate (positive water balance) combined with the geochemistry of the host rock geology are conducive to the formation of iron ferricrete and the development of ferruginous layers or zones within the vadose zone. This process results in the development of a restrictive or inhibiting layer/zone within the profile over time.

The degree of hardness of the evaporite is gradational, with soft plinthic horizons (very friable and easily dug with a spade or shovel), through hard plinthite soil (varying in particle size from sand to gravel, but no cementation) to nodular and hard pan ferricrete or hard plinthic (cementation of iron and manganese into nodules) that are not possible to free dig or brake with a shovel.

This classification is taken from Tardy et al., (1991), and forms the basis for the classification of the hard pan ferricrete or lateritic portion of the soil horizon in terms of its workability (engineering properties) and storage sensitivities.

The soil classification system takes cognisance of ferricrete and has specific nomenclature for these occurrences. The variation in the consistency of this layer, its thickness and extent of influence across/under the site are all important to the concept of a restrictive horizon or barrier layer that is formed at the base of the soil profile and/or close to the soil surface.

Where this horizon develops to a nodular form or harder structure (Nodular, Honeycomb and Hard Pan) the movement of water within the soil profile is restricted from vertical movement and is forced to move laterally or perch within the profile. It is this accumulation of soil water and the precipitation of the metals from the metal and salt rich water that adds progressively to the ferricrete layer over time. This situation will be very difficult to emulate or recreate if impacted or destroyed.

Important to an understanding of the development of the ferricrete is the geological time and presence of the specific soil and water chemistry under which the horizon forms.

Destruction of this impeding layer due to mining or related activities will result in the loss of soil moisture down the profile and the potential for ingress of polluted water and the inability of the flora to access the soil moisture as readily as in the pre-construction state.

6.4.2.6 Soil Erodibility and Compactibility

Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of a particular soil as well as the treatment of the soil.

The resistance to, or ease of, erosion of a soil is expressed by an erodibility factor ("K"), which is determined from soil texture/clay content, permeability, organic matter content and soil structure. The Soil Erodibility Nomograph (Wischmeier et al., 1971) was used to calculate the "K" value.

With the “K” value in hand, the index of erosion (IOE) for a soil can be determined by multiplying the “K” value by the slope (measured as a percentage). Erosion problems may be experienced when the IOE is greater than 2.

The majority of the soils mapped can be classified as having a moderate to high IOE in terms of the slope %, and a moderate to low IOE in terms of the organic carbon content and clay content.

However, the vulnerability of the “B” horizon to erosion once the topsoil and/or vegetation is removed must not be underestimated when working with or on these soils. Vulnerability of these horizons (B2/1) rates as medium to high when exposed, with the high rainfall and storm intensities playing a major factor in the erosion of unprotected materials.

The concerns around erosion and inter alia compaction, are directly related to the disturbance of the protective vegetation cover and topsoil that will be disturbed during any construction and operational phases of the mining venture. Once disturbed, the effects and actions of wind and water are increased.

Well planned management actions during the pre-costruction phase, will have a significant financial and social effect through the construction and operational phases, and will save time and money in the long run, and will have an impact on the ability to successfully close and rehabilitated an operation once completed.

6.5 Land Capability

6.5.1 Overview of land-use types

The Canadian Land Inventory and Land Capability Rating System was used as the basis to determine land capability classes for the soils within the Project. In terms of the Canadian system, four main land capability classes were identified in the Project. The classes as well as the criteria associated with each class are included in Table 6-33.

Table 6-33 Pre-construction Land capability Criteria (Source: Canadian Land Inventory and Land Capability System)

Land Capability Class	Criteria of Land Capability Class
Wetland	• Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water dependent.
Arable Land	• Land, which does not qualify as a wetland. • The soil is readily permeable to a depth of 750 mm. • The soil has a pH value of between 4.0 and 8.4. • The soil has a low salinity and Sodium Absorption Ratio (SAR) • The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100 mm in the upper 750 mm. • The soil has a slope (in %) and erodibility factor (K) such that their product is <2.0. • Occurs under a climate of crop yields that are at least equal to the current national average for these crops.
Grazing land	• Land, which does not qualify as wetland or arable land. • Has soil, or soil-like material, permeable to roots of native plants that is more than 250 mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100 mm. • Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.
Wilderness land	• Land, which does not qualify as wetland, arable land or grazing land.

The above criteria together with the soil information and geomorphological aspects gathered during the site visit allowed for the classification of the land capabilities.

The areas covered by each land capability type are included in Table 6-34 and mapped in Figure 6-83. This must not be confused with the actual current land use and habitat types.

Table 6-34 Land Capability as Percentage of the Study Area

Land Capability Rating	Area (Ha)	% Of area
1 = Arable	520.6200	26.35%
2 = Grazing	605.7083	30.66%
3 = Wilderness	168.8549	8.55%
4 = Wet Based	385.3178	19.50%
5 = Stream	120.5016	6.10%
6 = Man Induced	174.6321	8.84%
Total Area	*1 975.6347*	100.00%

Arable land: There are limited (26%) areas of potentially arable soils associated with this area, notwithstanding the fact that large areas return soil depths that are reflective of an arable status (at least 750 mm), the growth potential (nutrient status and soil water capabilities) and ability of these soils to return a cropping yield equal to or better than the national average is lacking. This is due mainly to the soil chemistry, the steepness of the terrain and to some extent the nutrient status. These variables reflect the natural conditions, and do not include any man-induced additives such as fertilisers or water. Impacts of existing land use (artisanal mining and farming) will also influence the overall area of arable potential. It is furthermore important to note that a significant portion identified as arable land contains high levels of aluminium and other toxic metals, which poses problems for the production of many food crops. It will therefore be better to utilise this land as low potential grazing land or conservation/wilderness areas.

Grazing Land: Grazing land makes out 31% of the study area. Within the project the classification of grazing land is generally associated and confined to the shallower and transitional zones that are well drained. These soils are generally darker in colour, and are not always free draining to a depth of 750 mm but are capable of sustaining palatable plant species on a sustainable basis, especially since only the subsoils (at a depth of >500 mm) are periodically wetted. The classification also makes allowance for the fact that the deeper soils are able to sustain the natural vegetation and plant growth, most of which is palatable to wildlife and domestic livestock.

Wilderness/Conservation Land: Only 8% of the area can be classified as having characteristics of wilderness or conservation land. The wilderness class is associated with the shallow rocky areas and soils with a structure stronger than strong blocky (vertic etc.), or shallow soil on a lithocutanic base. These soils are characteristically poorly rooted and at best support very low intensity grazing, or more realistically are of a wilderness character and rating.

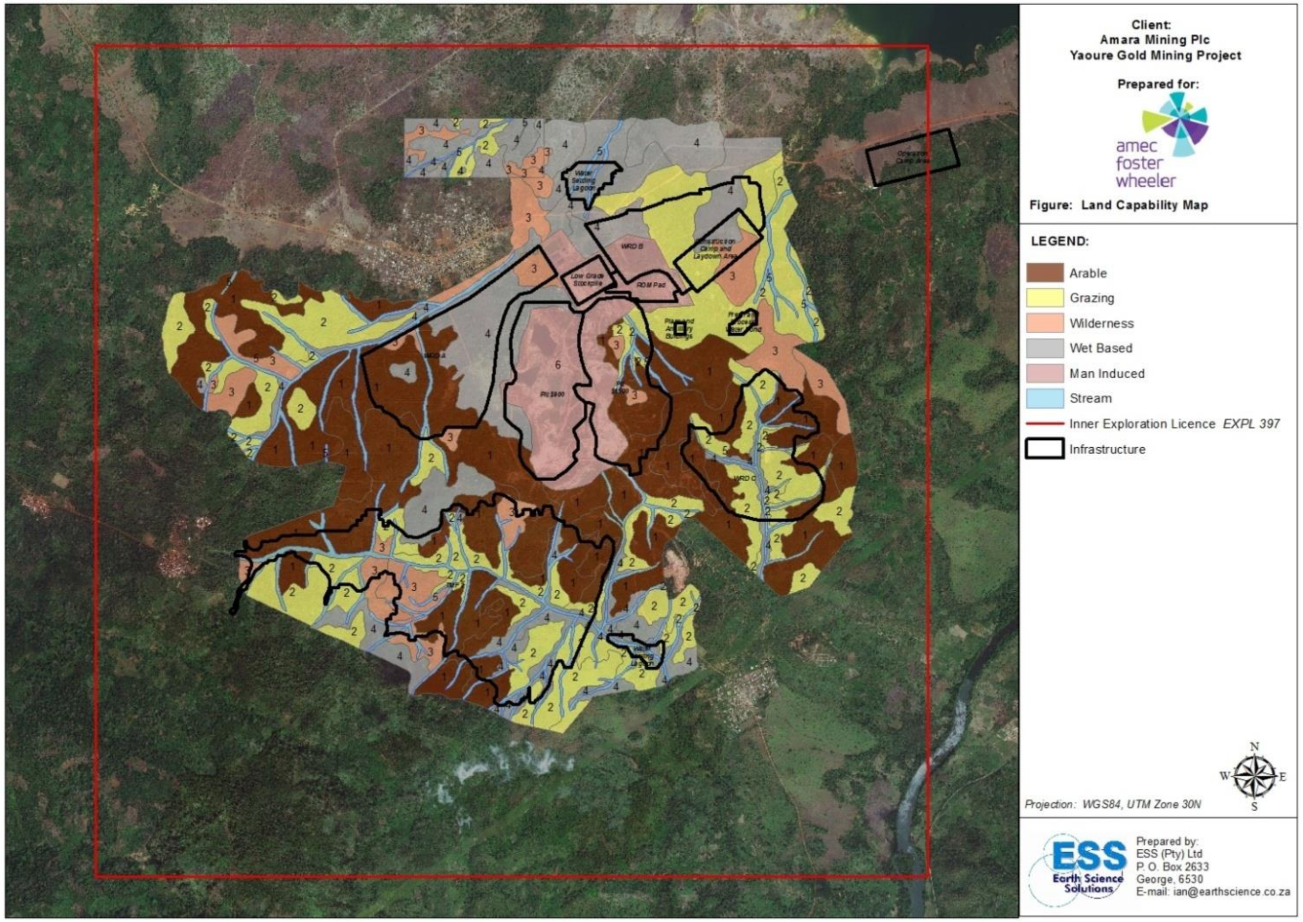
Wet Based Soils: It is important to note that wetland areas in this document are defined in terms of the wetland delineation guidelines as defined in the IFC PS 6 and the Wetland and Riparian Delineation Guidelines (DWA 2008) and the Guide to the Convention on Wetlands (1971) which use both soil characteristics, the topography as well as floral and faunal criteria to define the domain limits. Only the soils are described here, and as such the term wet based soils is used and not "wetlands".

A significant proportion (19%) of the study area classifies as having wet based soils. It is important to note that a significantly large area of the open pit and infrastructure development being planned encroaches on soils with a wet base classification. The wet based soils are dominated by hydromorphic soils (wet based) that often show signs of structure, and have plant life (vegetation) that is associated with seasonal wetting or permanent wetting of the soil profile.

The wetland soils are generally characterised by dark grey to black colours (organic carbon) in the topsoil horizons and are often high in transported clays and show variegated signs of mottling on gleyed backgrounds (pale grey colours) in the subsoil's. Wetland soils occur within the zone of soil water influence. These should not be mistaken as wetlands in terms of the delineation system, but should be highlighted as potential zones of sensitivity with the potential for highly sensitive areas associated with the prominent waterway that cross-cuts the proposed development.

These zones are considered very important, highly sensitive and vulnerable due to their ability to contain and hold water for periods through the summers and into the dry winter seasons.

Figure 6-83 Land Capability Classification of the Yaoure Gold Project



6.5.2 Current Land Use and Habitats

A land use and habitat survey was carried out as part of the ESIA process to identify land uses and habitat types and to assist in the identification of potentially sensitive biophysical and cultural-social areas associated with the Project. The area covered by the land use and habitat survey included the inner exploration area as well as a buffer zone on the outside to ensure that all alternative footprints were covered.

The following methodology was used to determine current land uses and habitat types:

- An initial desktop assessment which involved the following:
  - A manipulation of the digital terrain model (DTM) spatial imagery to enhance imagery, information retrieval and associated identification of land use and habitat categories. This data was obtained from the Client who had the area flown to obtain the imagery;
  - Identification and classification of land uses with a specific geometrical shape, e.g. roads, cultivated land, villages and hamlets, powerline servitudes, etc. This was achieved by using a Red Green Blue (RGB) colourful composition raw image technique of the spatial imagery.
  - Identification and classification of land uses and habitats with no specific geometrical shape. An image-enhancement technique, the Main Component Analysis (ACP) on the four image raw strips (Near Infra-Red, Red, Green and Blue) was applied to aid land category identification. This was supported by the calculation of Normalised Difference Vegetation Index (NDVI) or vegetation index standard that categorises the plant formations depending on their photosynthetic intensity. It allows distinguishing between open surface and covered areas of vegetation;
  - Land use and habitat classes were identified as a result of the desktop analysis;
  - On the basis of the foregoing process, two hundred representative sample points were selected to verify land use and habitat types during the field investigations.
- A land use and habitat survey: based on the initial classification of the study area, 200 points were selected to verify the land uses, habitat types and the categories. The information gathered on site allowed for the update of the land use map;
- To enhance map accuracy and address areas of uncertainty, another validation survey was undertaken. During this survey 100 points were

identified of areas where there were still some uncertainties and where land use was less obvious; and

- The final step phase of the survey was to update the land use and habitat map and to calculate the areas associated with the various land uses.

In addition to the above methodology Amec Foster Wheeler also considered the outcome of the previous land use study undertaken in 2007 as part of the ESIA for Cluff Gold, the artisanal miner survey undertaken by Perseus in December 2014 and the 2D Cultural Heritage survey undertaken with the communities to identify grave and sacred sites. These findings were incorporated in the land use map.

The results of the study and the main land use and habitat types identified in the Project area are included in Table 6-35.

Table 6-35 Land Use and Habitat Types

Land Use or Habitat Type	Description
Perennial agricultural land	Perennial agriculture in the Project and study area consists mainly of woody plants, with a longer life cycle, including cacao and coffee
Annual agricultural land	Consists of areas where there are annual crops of which the life cycle lasts one year. This category also includes fallow land where the area has been abandoned for between one and two years.
Villages and hamlets	Villages and smaller hamlets visible within the Project area
Open soils	Areas associated with natural open soils (floodplains, beach areas next to lake Kossou) and outcrops
Artisanal mining	Exposed soils and activities specifically related to artisanal mining
Rivers and water bodies	All streams including non-perennial drainage lines and Lake Kossou
Seasonally wet soils	Areas which are prone to seasonal flooding
Savannah	Grassy formations with a carpet of grasses and forbs where trees and shrubs are absent
Shrubland savannah	Grassland with shrubs but at a relatively low percentage, (generally between 15-30% of shrubs)
Dense shrubland savannah	Grassland where shrubs are present, covering between 40-60% of the area
Woodland savannah	Woodland savannah consists of grassland with the presence of forest (between 30-40%) and closed shrubs (60-70%)
Degraded forest	Degraded forest is primary forest of which the original cover has been altered through unsustainable exploitation resulting in a change of its structure, processes, functions and its dynamics thereby compromising its short and medium term ability to adapt to its former ecosystem functionality. Due to the disturbed nature of the various forest types, for the purpose of the land use map, these were all grouped together as degraded forest.
Secondary forest	Secondary forests originate where the original primary forest has been largely cleared (usually 90%) and where the original forest is replaced by woody vegetation. In general, secondary forests grow naturally where land has been abandoned after shifting agriculture, sedentary agriculture, pasture, or failure to establish commercial plantations.
Riparian forest	Riparian forests are specific forest formations which are associated with rivers. These formations are located in ecological transitions between aquatic habitats and land areas. The riparian forests are subject to frequent flooding, as opposed to riparian forests.
Gallery forest	Gallery forests are characterised by their joined canopy above a river, stream, or a wetland area of which the presence of water may be temporary.
Infrastructure	Includes roads, powerlines and tracks.
Current mining activities	Current mining activities includes all footprints and infrastructure associated with historic and existing Yaoure Project.

For the purpose of the land use mapping, however, similar categories has been mapped together (see Figure 6-94). The areas covered by each land use or habitat are included in Table 6-36.

The Project area and associated habitats have been extensively modified through human activities. The only remainders of the original habitats are in the form of pockets of degraded forest.

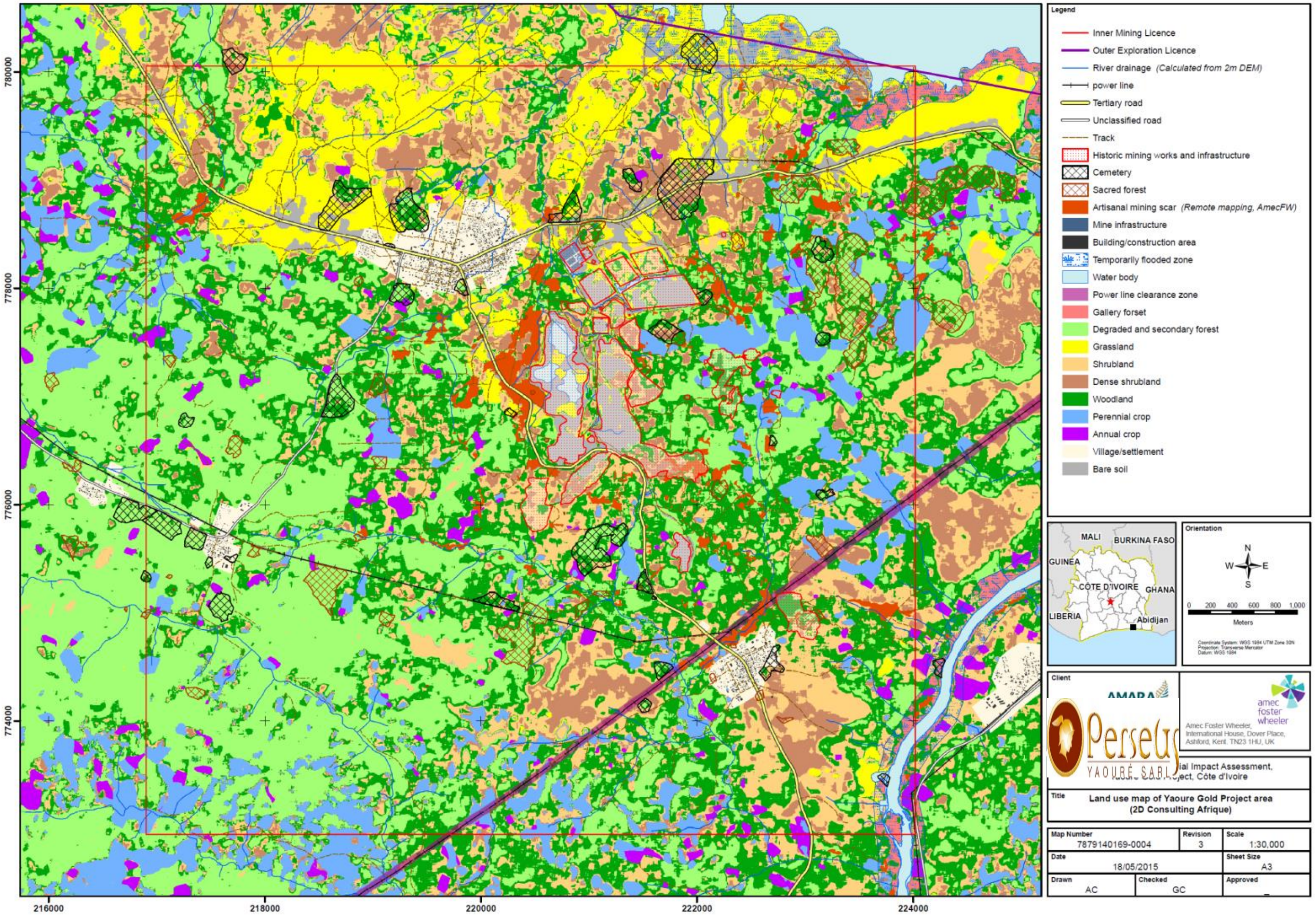
Table 6-36 Yaoure Gold Project Land Use and Habitat Types

Land use and habitat type	Area (ha)	% of Inner Licence Area	Area covered by proposed infrastructure (ha)
Bare soil	191	3.8%	91
Village/settlement	129	2.6%	-
Annual crops	87	1.7%	14
Perennial crops	338	6.7%	34
Cemetery	111	*	19
Sacred forest	110	*	19
Power line clearance zone	47	*	1
Degraded and secondary forest	1401	27.7%	190
Shrubland	826	16.3%	128
Dense shrubland	381	7.5%	53
Woodland	1240	24.5%	231
Grassland	412	8.2%	47
Gallery forest	21	0.4%	-
Bandama River	12	0.2%	-
Lake Kossou	13	0.3%	-
Water bodies	11	0.2%	13
Temporarily flooded zone	76		-

* Cemeteries, sacred forest, power line and temporarily flooded zone shapes all overlay the other classifications.

The area of agricultural land (annual and perennial crops) that will be covered by Project infrastructure amounts to 48 ha.

Figure 6-94 Land Uses and Habitats associated with the Yaoure Project (<u>Note:</u> A larger format of the area with better readability is provided in Error! Reference source not found.**.)**



6.6 Biodiversity

6.6.1 Overview

This section summarises the results of biodiversity baseline surveys conducted within the Project area between November 2014 and May 2015 (Table 6-37). The strategic pre-scoping study (AMEC, 2014) identified five groups that would require further surveys. Additional small mammal surveys were also judged necessary to undertake, given the potential presence of threatened species in this area. Therefore, field surveys were conducted for six groups in total:

1. Birds;
2. Reptiles and amphibians;
3. Flora;
4. Freshwater microalgae, macroinvertebrate and fish;
5. Large mammal; and
6. Small mammal.

Table 6-37 Summary of biodiversity baseline surveys completed in the Project area

Topic	Survey period	Field study team
Bird	16-29 January 2015	Dr. Bernard Ahon
Reptile and amphibian	1-20 May 2015	Dr. Johannes Penner and Dr. Nono Gonwouo LeGrand
Flora	1-18 April 2015	Dr. Carel Jongkind and Jan Mertens
Freshwater studies	1-15 April 2015	Dr. Félix Koffi Konan (Ichthyofauna) Dr. Yves Kotchi Bony (Benthic macroinvertebrates) Dr. Marie Paulette Adon (Microalgae) Juan Potgieter (Ichthyofauna)
Large mammal	15 November – 24 December 2014	Dr. Geneviève Campbell and Dr. Jean-Claude Koffi Béné
Small mammal	16-29 January 2015	Dr. Bertin Akpatou

The data collected aimed to provide baseline conditions for these six groups, and to update previous rapid assessments that were conducted in 2006-2007 as part of the ESIA for Cluff Gold plc. (Tano et al., 2007). In the aim of compiling a comprehensive species list for the different groups, sampling was undertaken in the alternate season to the 2006-2007 surveys to complement results whenever possible.

Results are presented with particular focus on globally threatened species, and species that could trigger Critical Habitat according to criteria 1-3 of the IFC (IFC, 2012). Globally threatened species are species listed either as Critically Endangered (CR EN), Endangered (EN) or Vulnerable (VU) in the IUCN Red List of Threatened Species.

They may also include nationally protected species and species not recently assessed by the IUCN Red List, but considered threatened according to expert opinion. Identification of Critical Habitat is based on five main criteria, from which only the first three could apply to this project:

1. Globally or nationally Critically Endangered or Endangered species;
2. Restricted-range or endemic species;
3. Concentrations of migratory and congregatory species;
4. Highly-threatened and unique ecosystems; and
5. Key evolutionary processes.

This section provides a descriptive summary of baseline surveys, and a separate Critical Habitat Assessment can be found in **Error! Reference source not found.**.

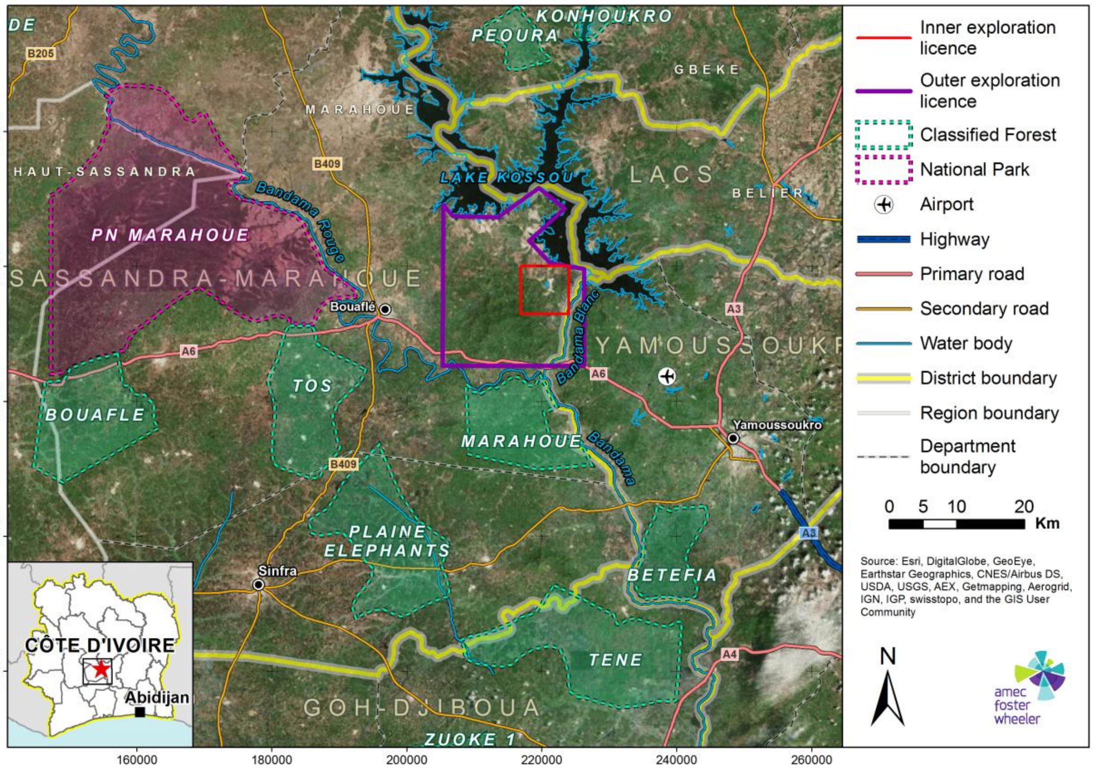
6.6.2 Project Area and Area of Influence

The Project area consists of an 'Outer Exploration License' (OEL) covering approximately 440 km^2, including a smaller 'Inner Exploration License' (IEL) of approximately 50 km^2 in size (Figure 6-10). The Project area is located in a transition zone between two biomes, the Guineo-Congo forest and the Sudan-Guinea savannah biomes. Therefore, high species richness is expected since species belonging to these two different biomes may be present.

No protected area or internationally recognised areas intersect with the Project area, with the closest protected area being located approximately 12 km away from the IEL (namely the Marahoue Classified Forest, see Figure 6-105). From looking at recent satellite imagery, Marahoue Classified Forest appears highly degraded, with many plantations, villages and roads within its boundaries. This is reflective of the high level of deforestation and encroachment in protected areas throughout the country (Fischer, 2004; Campbell et al., 2008; Bitty et al., 2015).

The main hydrological features present in the Project area are the Kossou Lake, which lies at the northern end of the IEL and OEL, and the Bandama River, which flows to their eastern boundaries. A hydroelectric dam was built on the Bandama River in 1972, and now regulates the waterflow on the Bandama River.

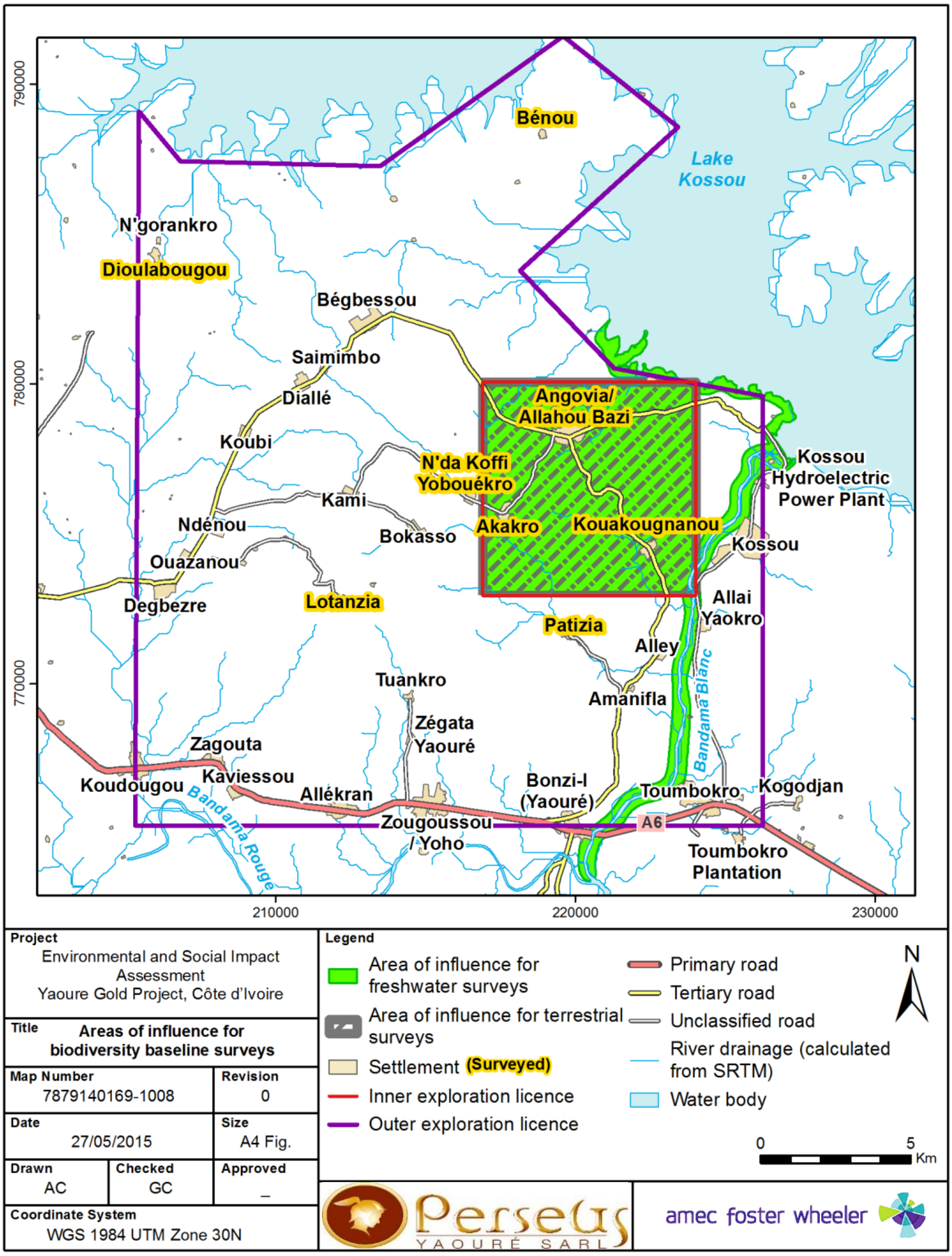
Figure 6-10 Location of the Project area



The IEL was considered the main area within which to conduct biodiversity surveys (

Figure 6-116). This area was meant to include the footprint of the project's infrastructure and related facilities, as well as to include a wider area of influence to encompass areas that may be affected by indirect impacts. Considering the highly degraded nature of the area, a few surveys were also conducted within the wider OEL where more original vegetation remained, in the vicinity of the villages of Benou, Patizia, Lotenzia and Diaboulougou, to collect data more representative of baseline conditions. A larger area of influence was selected for the freshwater surveys, as indirect impacts may affect a wider area, including the Bandama basin and its tributaries.

Figure 6-11 Areas considered during biodiversity baseline surveys



6.6.3 Baseline surveys summary

6.6.3.1 Birds

<u>Description</u>

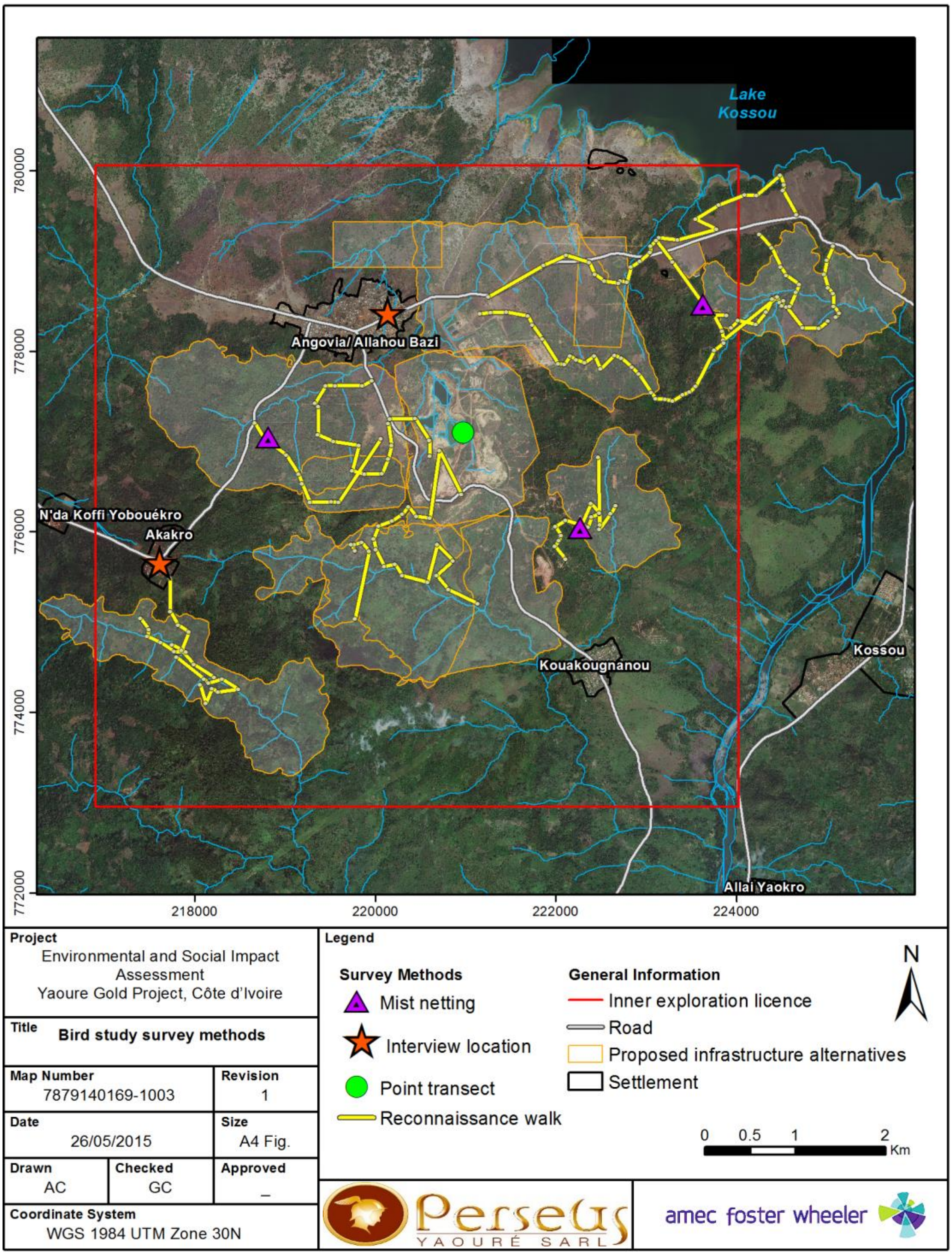
Surveys were carried out in the dry season, to increase the chances of detecting the presence of migratory species. Four different methods were used to assess species presence (see also

Figure 6-12):

1. Interviews;
2. Reconnaissance walks;
3. Fixed points sampling; and
4. Mist netting.

Interviews helped to gather a general overview of species present and their threats, as well as their local names. Fixed points sampling was only used at several locations within the previous pit area, which provided an appropriate view point over the area to record migratory species in particular. Reconnaissance walks were conducted along approximately 32 km in potential habitat, and aimed to cover as much of the alternative options as possible. During reconnaissance walks, playback calls were sometimes used to increase sampling effort. Three mist netting locations were selected to target more specifically cryptic species that may be missed by the other sampling techniques.

Figure 6-12 Sampling locations for bird surveys



Summary of main findings

Overall, 5333 birds were observed belonging to 172 species from 49 families. The family with the highest number of species was Pycnonotidae, with 13 species.

Species belonging to both the Guineo-Congo forest and Sudan-Guinea savannah biomes were recorded in the area. For the Guineo-Congo forest, 28% of all species belonging to this biome in Côte d'Ivoire were recorded from the area, and 18% of all species belonging to the Sudan-Guinea savanna biome were recorded as present in this area. The majority of species recorded from the Project area are resident species, with only approximately 17% of the total species that are migratory (i.e., 28 species).

Among all species detected, only one is globally threatened according to its IUCN Red List status, the Vulnerable Timneh parrot (*Psittacus timneh*). Three other species are classified as Near-Threatened (NT): the green-tailed bristlebill (*Bleda eximius*), the black-headed rufous warbler (*Bathmocercus cerviniventris*), and the copper-tailed glossy starling (*Lamprotornis cupreocauda*). These three NT species are also restricted-range, meaning their global breeding range is less than 50,000 km^2. Another restricted-range species was confirmed for the area, the Sharpe's apalis (*Apalis sharpii*), but this species is not listed as threatened according to the IUCN Red List. These four restricted-range species represent 28% of the restricted-range species recorded for Côte d'Ivoire.

Nine species were identified as endemic to West Africa: the Senegal parrot (*Poicephalus senegalus*), the violet turaco (*Musophaga violacea*), the Sharpe's apalis (*Apalis sharpii*), the green-tailed bristlebill (*Bleda eximius*), black-headed rufous warbler (*Bathmocercus cerviniventris*), the bearded barbet (*Lybius dubius*), the copper-tailed glossy starling (*Lamprotornis cupreocauda*), the common Gonolek (*Laniarius barbarus*) and the red-vented Malimbe (*Malimbus scutatus*).

The species diversity was more or less similar across all the sites surveyed within the Project area. However, the VU Timneh parrot, and the three other NT species were all associated with forested habitat, and thus protection of the remaining forested patches should be given priority.

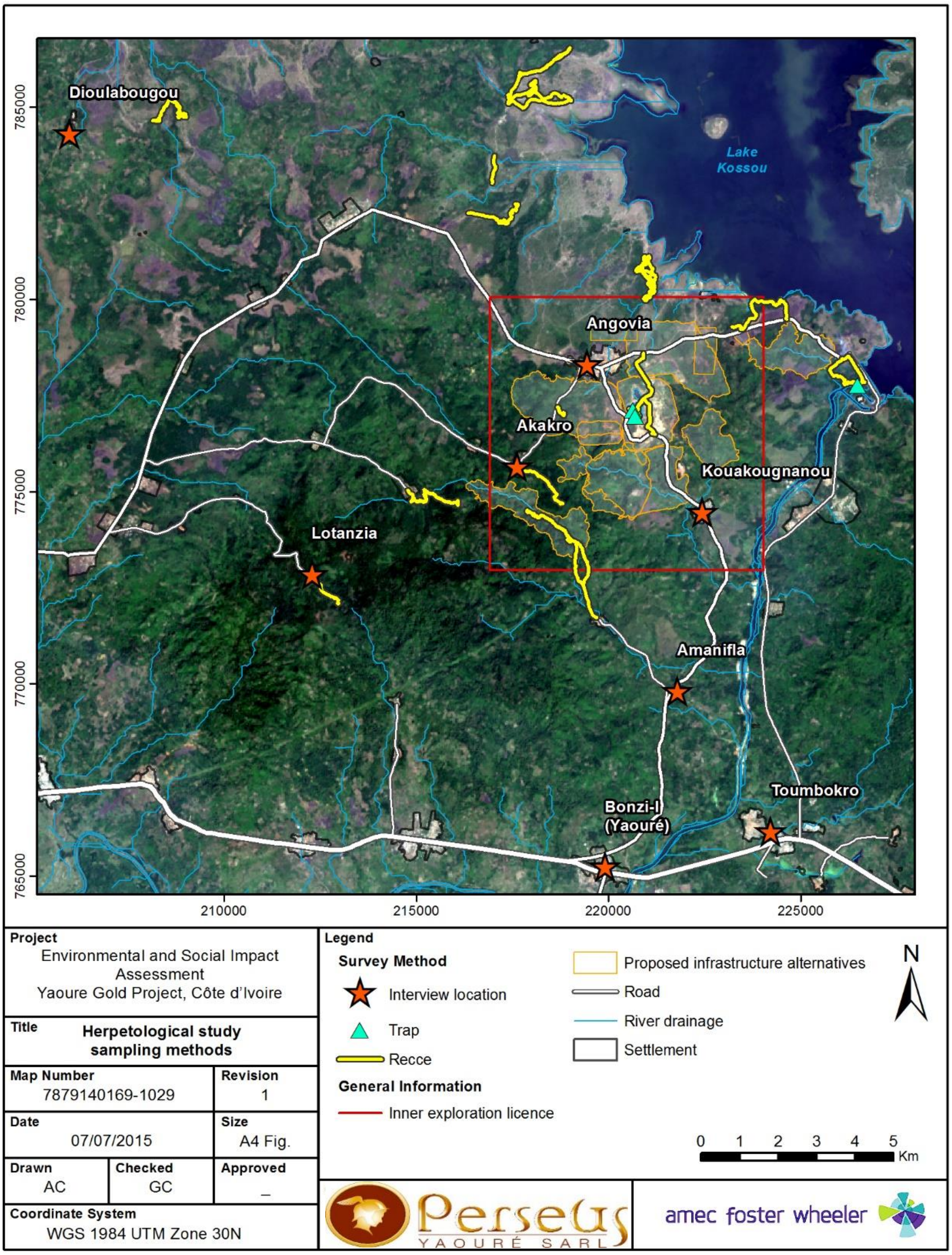
Details of the Avifauna Baseline Study are contained in **Error! Reference source not found.**.

6.6.3.2 Reptile and Amphibian

Description

Surveys were carried out during the beginning of the rainy season. Survey methodology consisted of three different methods: (i) interviews; (ii) day and night reconnaissance walks; and (iii) drift fences with funnel trapping (Figure 6-13). Specimens were identified in the field by sight or sound, or in unclear cases were brought back to the laboratory. Selected specimen were preserved in ethanol and deposited in the herpetological collection of the Museum für Naturkunde in Berlin, Germany.

Figure 6-13 Sampling locations for amphibian and reptile surveys

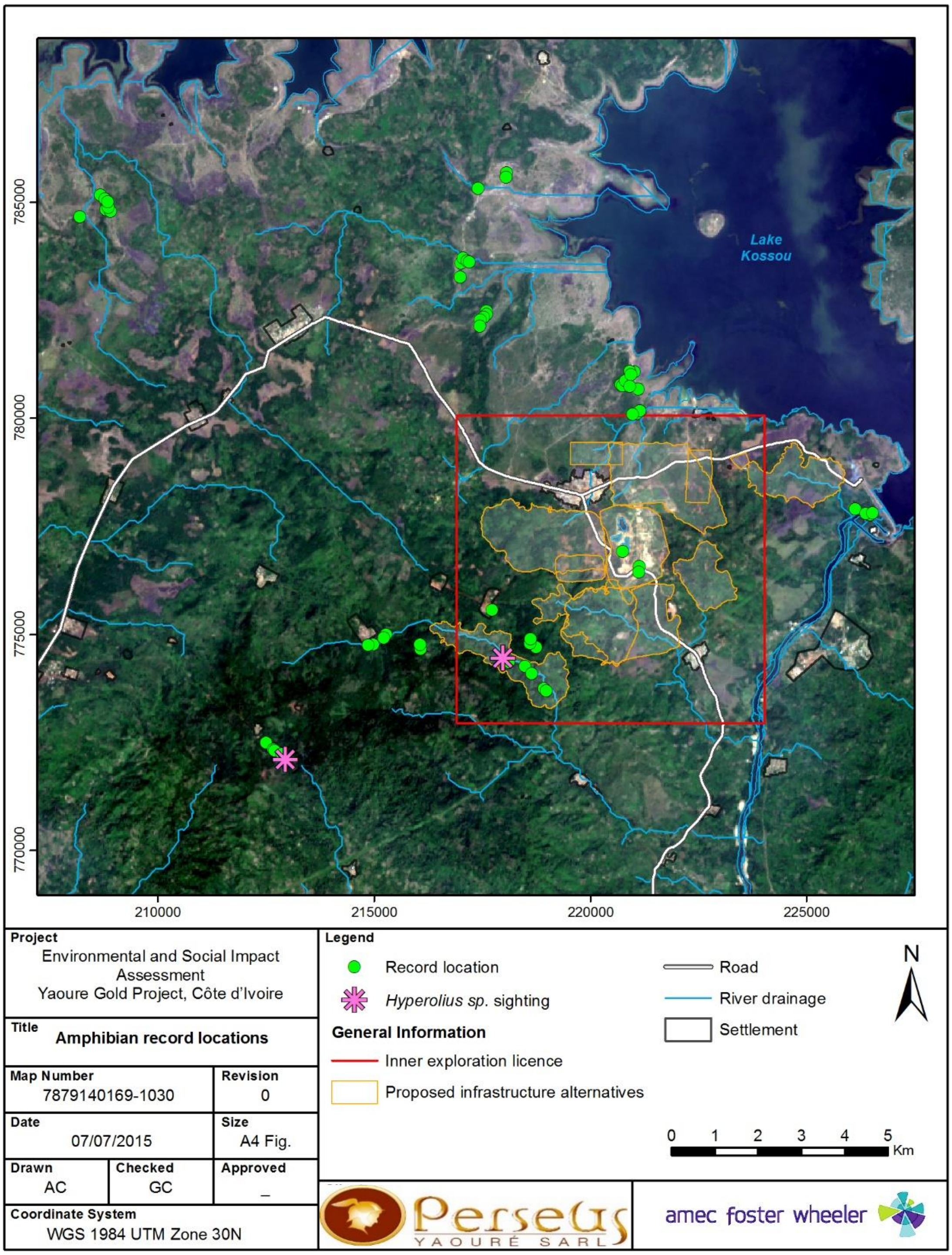


Summary of main findings

Relatively high amphibian diversity was recorded from the area, with 29 species. This is a consequence of the location of the Project area, being located in the transition zone between two biomes (i.e. Guineo-Congo forest and the Sudan-Guinea savannah biomes). Therefore, species associated with both forested and savannah habitats were recorded from the area. None of the amphibian species are listed as threatened on the IUCN Red List, however one species is endemic to Côte d'Ivoire (i.e. *Kassina schioetzi*) and another may be a new species (*Hyperolius* sp.). Indeed, four frog specimens were collected from two different locations (

Figure 6-14) and identified as belonging to the genus *Hyperolius*, but genetic analyses revealed these specimens to be different than any known species within that genus. Further morphological analyses, genetic and acoustic analyses would be required to ascertain whether there is actually a new species present in this area.

Figure 6-14: Amphibian record locations



High reptile diversity was also found in the Project area, with 31 species directly observed in the field and a further four species reported during interviews. None of these species are listed as threatened, however the majority of these species have not been assessed by the IUCN Red List. Other species were reported in the literature as present in this area according to their distribution range, amongst which two crocodile species which are listed as Vulnerable and Critically Endangered on the IUCN Red List. However, no crocodiles were seen during surveys, or reported by the fisherman of the Kossou Lake and Bandama River. The artisanal mining along the Bandama River has led to soil erosion and a heavy silt load in the section of the Bandama River between the Kossou dam and the bridge at Bozi, which renders the habitat inhospitable for the fauna associated with this environment.

It should be noted that even though most of these species are not listed as threatened, they are regularly harvested for local consumption or to be used as fetish, or in the cases of snakes, systematically killed because of fear. The amplitude of these impacts on their population trends is not well understood, but it is likely that updating the status of these species may reveal more threatened species then previously thought.

Details of the Reptile and Amphibian Baseline Study are contained in **Error! Reference source not found.**.

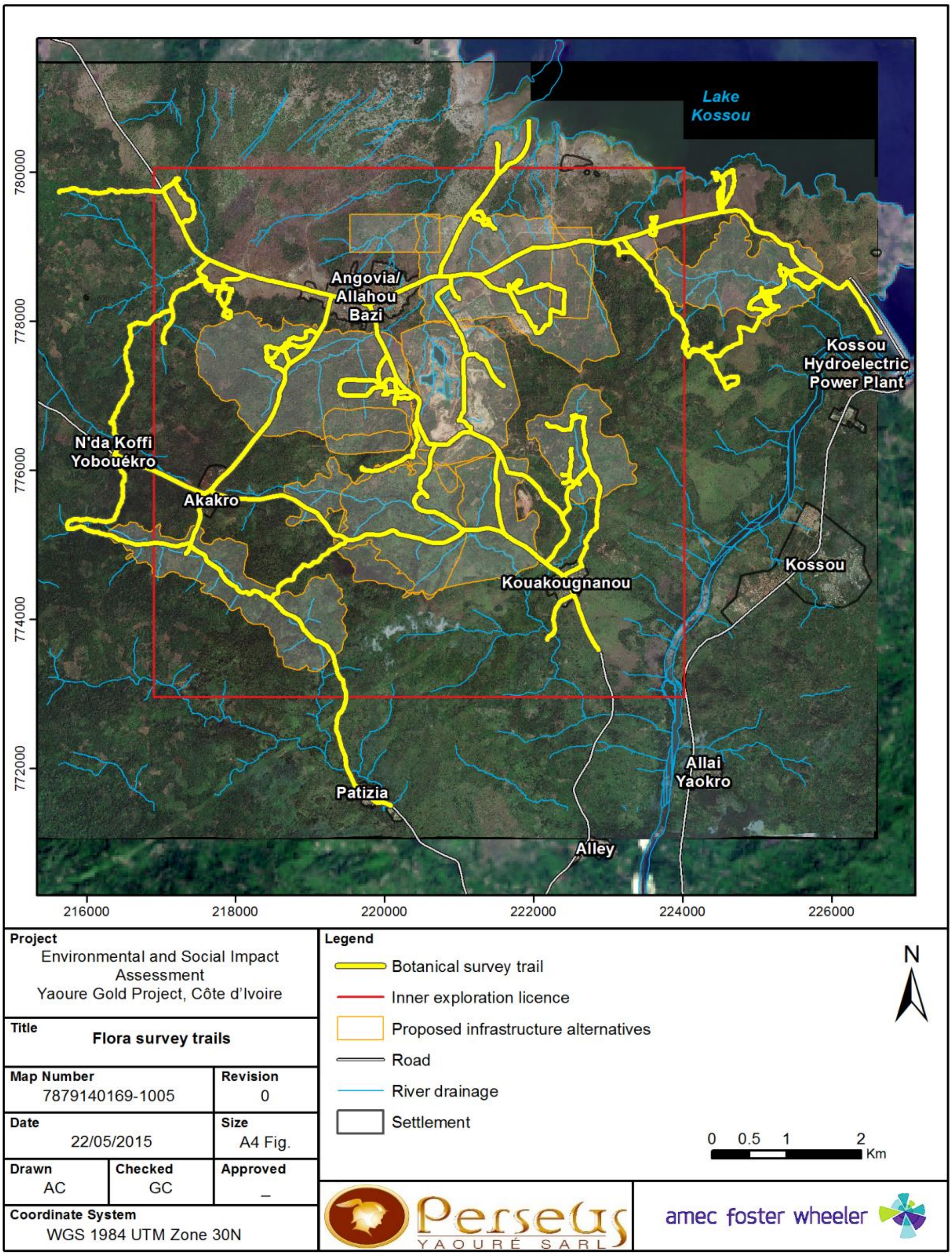
6.6.3.3 Flora

<u>Description</u>

Botanical surveys were conducted at the beginning of the rainy season, when most plants are flowering to facilitate identification. The methodology employed consisted of reconnaissance walks within habitat retaining most of their original vegetation, as identified from satellite imagery (

Figure 6-20). All habitat types and alternative option locations were covered, with a total survey effort of 87 km of reconnaissance walks (on foot or by car). A herbarium was assembled, and for species which could not be identified on-site, further consultation with existing botanical collections and experts took place in the Netherlands. Specimens were sent to the Botanic Garden of Meise in Belgium after their final identification, to be integrated into their general collection.

Figure 6-20 Sampling locations for botanical surveys



<u>Summary of main findings</u>

Overall, 330 species were confirmed to occur within the Project area. Among these species, eight are globally threatened species, listed as Vulnerable on the IUCN Red List. The eight globally threatened species consisted of seven tree species and one liana species. The liana species, *Strychnos millepunctata*, is also endemic to Côte d'Ivoire and threatened by habitat loss.

During the previous botanical survey in 2006-2007 (Tano et al., 2007), what was thought to be a new tree species belonging to the genus *Nuxia* was recorded from the area (Tano et al., 2007). However, further investigations revealed that this species was in fact *Nuxia congesta*, a widespread species characteristic of forest above 1,000 m altitude, which had not been recorded previously from this area of Côte d'Ivoire (Adou Yao, 2011). This species can only be found on a few forested hilltops within the Project area.

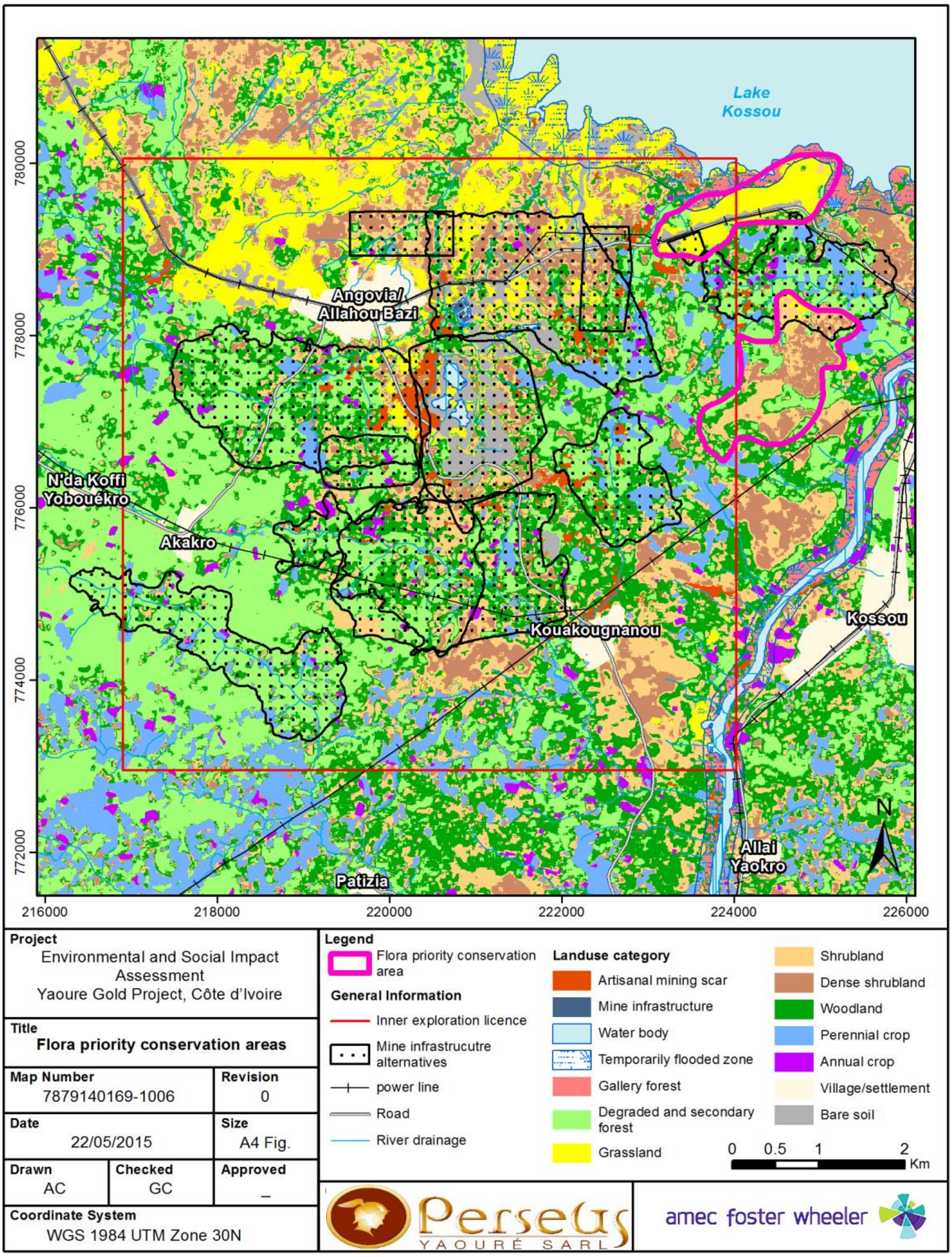
With the help of two local herbalists, 54 species were identified as being used locally in traditional medicine, and/or as source of food, natural dye, soap, or poison for pest species.

The vegetation within the Project area was generally found to be highly degraded, and under continuous threat from habitat loss from agriculture and artisanal mining activities. The best-preserved areas that were identified as priority areas for flora conservation were the herbaceous vegetation on rocky soils, lateritic hardpan and the few patches of dry forest left on hilltops (

Figure 6-15).

Details of the Flora Baseline Study are contained in **Error! Reference source not found.**.

Figure 6-15 Location of flora priority conservation areas



6.6.3.4 Freshwater

Description

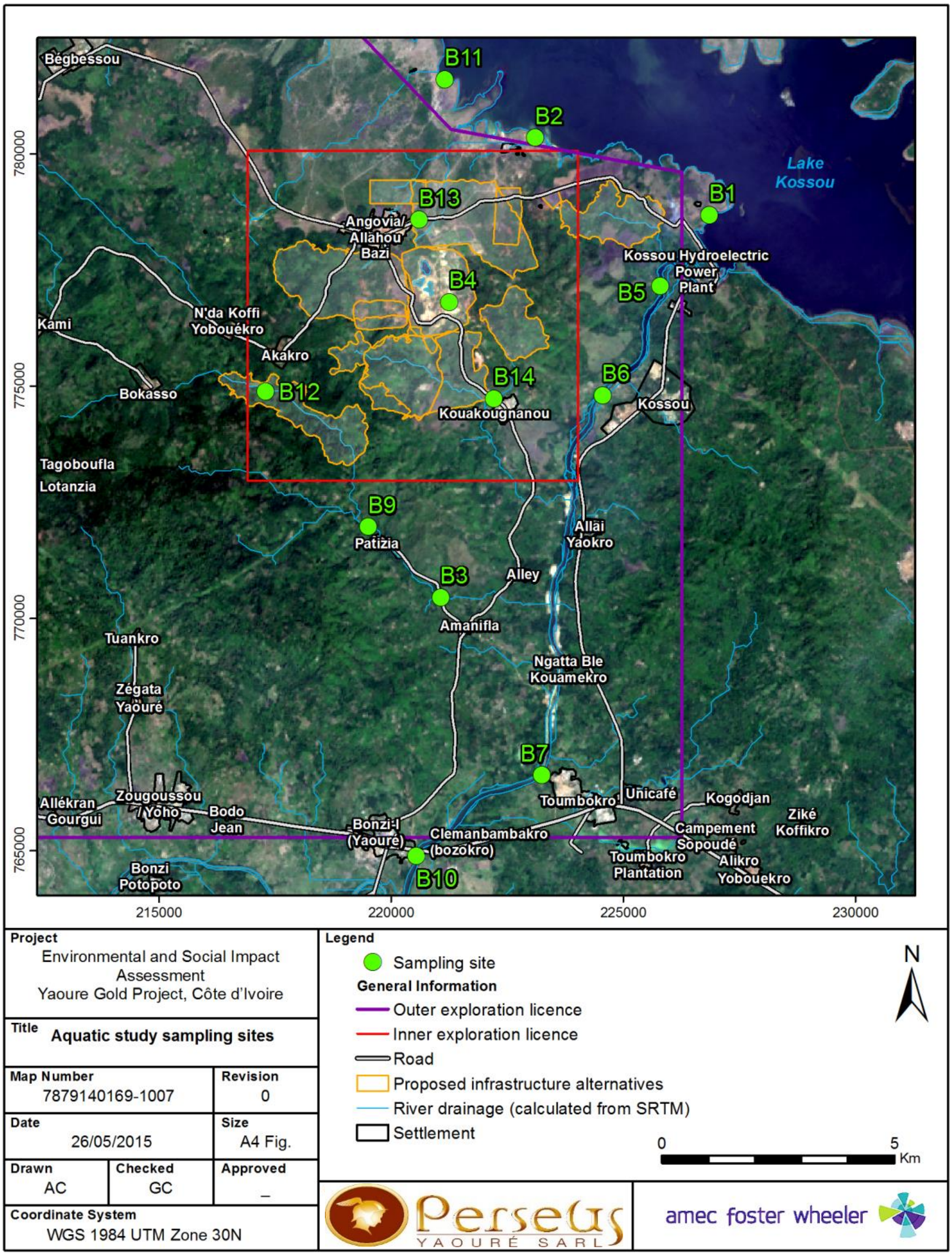
Freshwater surveys were conducted at the start of the rainy season to complement the previous survey that was conducted in the dry season (Tano et al., 2007). The following freshwater groups were considered in this study:

- Microalgae;
- Benthic macroinvertebrates; and
- Fish.

The survey design included 13 sampling points, distributed as follow: 3 along Kossou Lake (B1, B2, B11), 4 along the Bandama River between the Kossou dam and the bridge at Bozi (B5, B6, B7, B10), 5 along the tributaries of the Bandama River (B3, B9, B12, B13, B14), and one in the artificial lake created at the previous mining pit location (B4), see

Figure 6-16.

Figure 6-16 Sampling locations for freshwater surveys



Different methods were used to sample microalgae, which consisted of phytoplankton and periphyton. Plankton net and hydrological bottle were used for sampling phytoplankton. For periphyton, samples were collected by scraping submerged plants, stones or branches. Benthic macroinvertebrates were sampled using a Van Veen grab and using the kick sample technique. For both microalgae and macroinvertebrates, identification and analysis of results took place in the laboratory.

Sampling of fish was conducted using gill nets of different mesh size, and using electrofishing on smaller watercourse. Identification was performed mainly on-site, but when identification was not possible, specimens were preserved in ethanol and identified at the laboratory. Further consultation with fisherman took place, and identification of their catches helped in assessing species richness.

Summary of main findings

A total of 222 taxa (including species and variety) of microalgae were observed during the study, belonging to eight phyla, divided into 75 genera and 44 families. The most diverse phylum was Chlorophyta, with 100 taxa sampled. Higher microalgae diversity was found on the Kossou Lake, at sampling sites B1, B2 and B11. The lowest microalgae diversity was found at the old mining pit location, B4.

Concerning the benthic macroinvertebrates, a total of 2776 individuals were sampled from four groups: insects, molluscs, worms and crustaceans. These included 44 taxa belonging to 37 families and 10 orders. The majority (i.e., 78%) of the individuals collected were of the order Basommatophora. Insects were found to be the most diverse group, representing approximately 80% of the taxonomic richness.

The results from the microalgae and macroinvertebrate sampling indicate a low water quality in general, with several pollution indicator species present.

In total, 64 species of fish were identified, belonging to 35 genera and 16 families. If considering the previous survey that was conducted in 2007, this brings the total of fish species for the Project area to 70 species. Higher fish diversity was observed in the Bandama River (i.e. 52 species) than in the Kossou Lake (i.e. 36 species) and in the Bandama tributaries (i.e. 14 species). No fish were found at sampling site B4, which corresponds to the old mining pit.

Two species are threatened according to the IUCN Red List of Threatened Species: one EN species *Mormyrus subundulatus*, and one VU, *Tilapia busumana*. Three species recorded during these surveys are also NT: *Raiamas nigeriensis*, *Marcusenius furcidens* and *Tilapia walteri*. The latter species is also endemic to Côte d'Ivoire and possess a restricted range distribution, along with *Synodontis bastiani* and *Synodontis punctifer*. This survey also helped to complete the fish species list for the Bandama River, adding three species that hadn't been recorded previously (i.e. *Tilapia busumana, Tilapia walteri* and *Pellonula vorax*).

The hydrological system in the Project area is already under significant threat from historical and current artisanal mining activities. It is a particularly sensitive and vulnerable ecosystem, which constitutes also a primordial resource for local communities. Fishing is a common activity on the Bandama River and the Kossou Lake and the most heavily fished species that were identified were *Tilapia* spp., *Chrysichthys* spp. and *Brycinus* spp.

The details of the Freshwater Species Baseline Study are contained in **Error! Reference source not found.**.

6.6.3.5 Large mammals

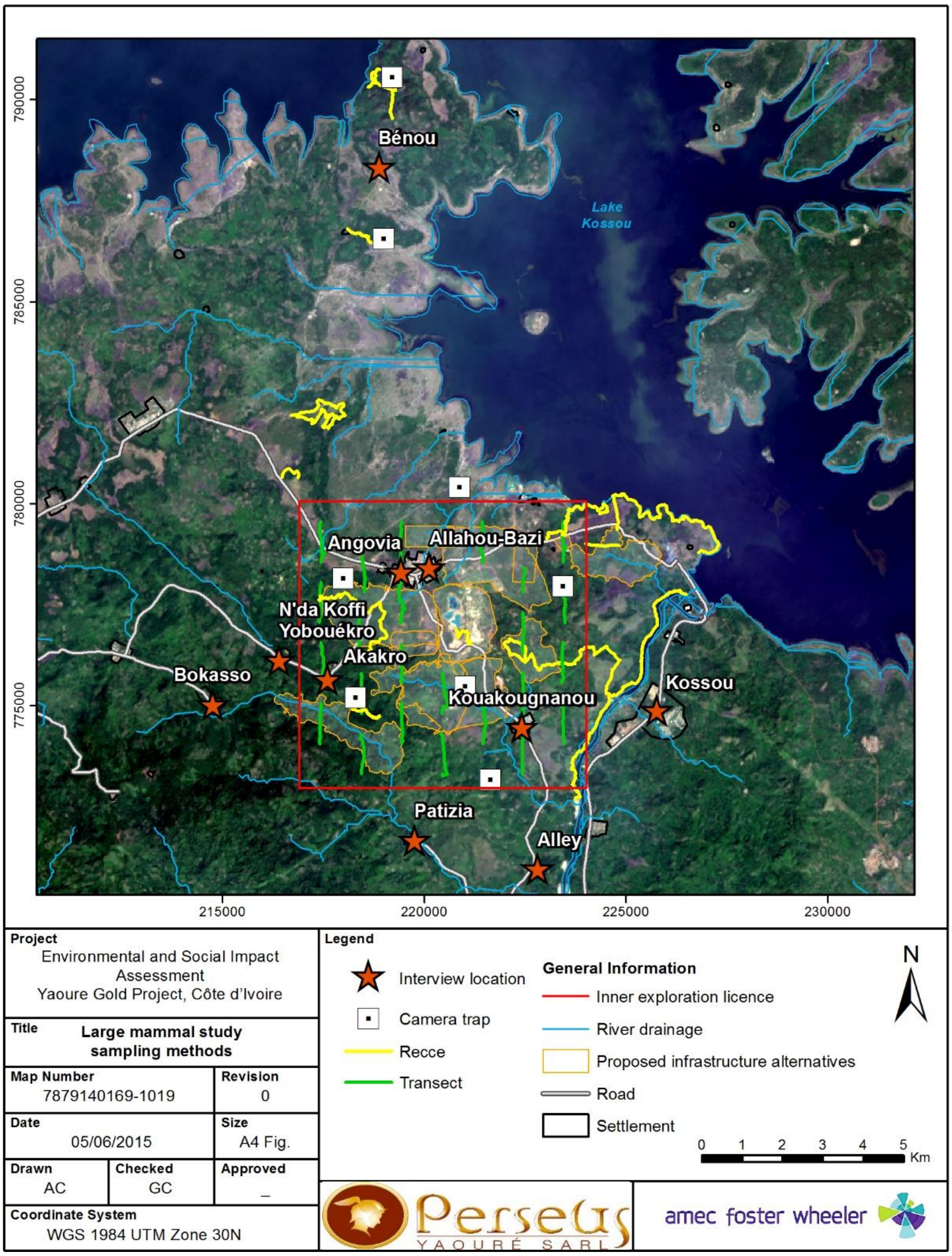
Description

Large mammal surveys, including primates, were conducted in the dry season. Four different methods were used to gather baseline data on the diversity, distribution and relative abundance of large mammal species for this area (

Figure 6-17):

1. Interviews;
2. Reconnaissance walks (recces);
3. Transects; and
4. Camera trapping.

Figure 6-17 Sampling locations for large mammal surveys



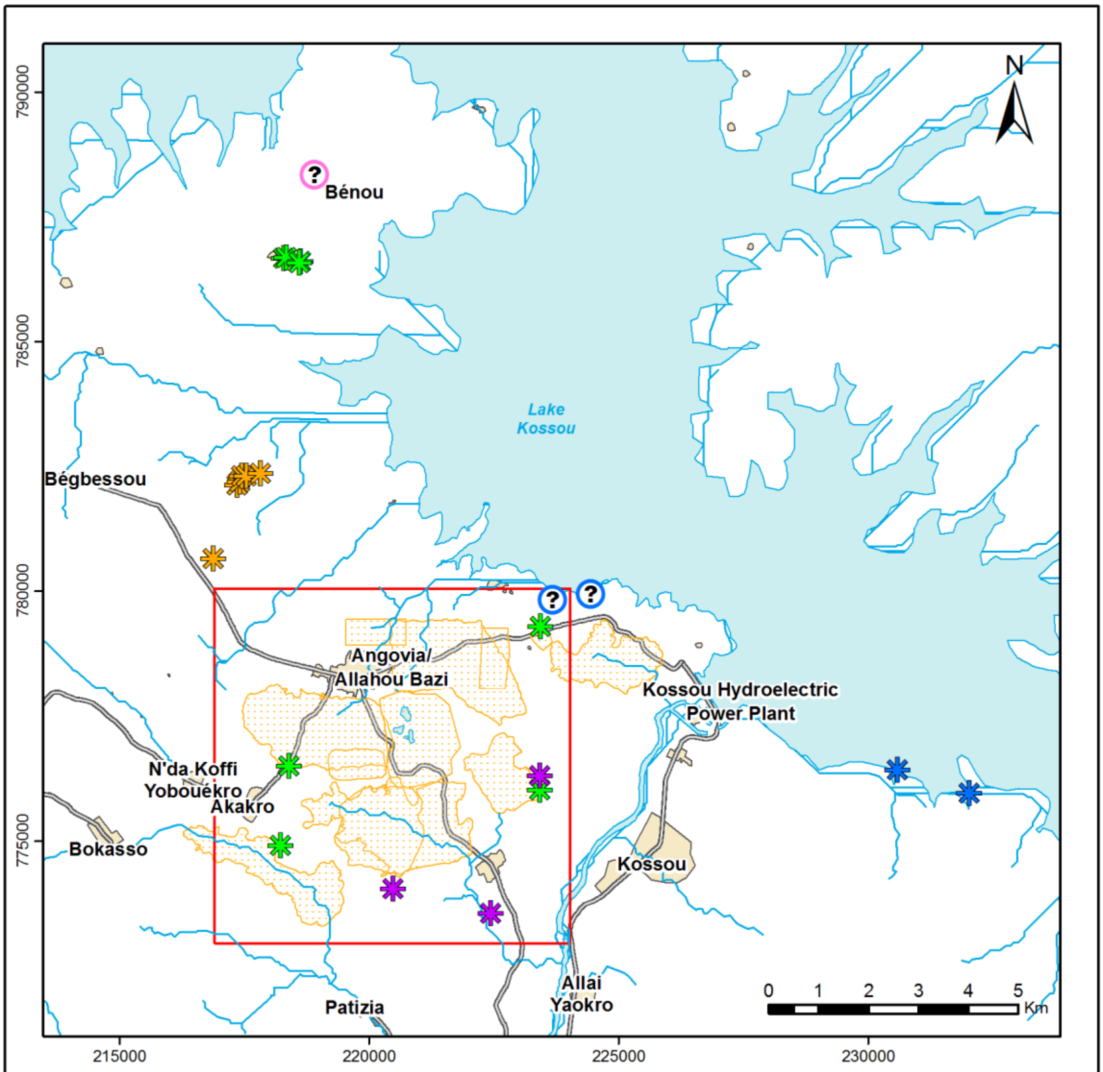
Interviews were conducted in 10 villages located within the IEL and its vicinity. Results from interviews helped to get a global picture of species present and target locations that would warrant further surveys, particularly areas where threatened species were reported. Reconnaissance walks were conducted within these targeted areas along 47 km to confirm the presence of large mammal species. To assess spatial distribution and relative abundance within the IEL, 23 km of transects were completed. In addition, eight camera traps were placed in habitat most likely to harbour high mammal diversity, for a survey effort of 274 camera trapping days.

Summary of main findings

A total of 26 species were reported to occur in the area. Among these, three species are listed as Vulnerable on the IUCN Red List of Threatened Species (i.e. *Phataginus tricuspis*, *Hippopotamus amphibius* and *Kobus kob kob*). A further three species are protected under national law. None of these nationally protected species are listed on the IUCN Red List. No primate species of conservation concern was recorded from the area. The six globally threatened species were associated with different habitat types, and thus distributed throughout the IEL and surrounding areas, except for the most degraded parts (i.e. at the previous pit location and closer to villages,

Figure 6-18).

Figure 6-18 Distribution of globally threatened large mammal species



Project	Environmental and Social Impact Assessment Yaoure Gold Project, Côte d'Ivoire
Title	Globally threatened large mammal species
Map Number: 7879140169-1020	Revision: 0
Date: 05/06/2015	Size: A4 Fig.
Drawn: AC; Checked: GC	Approved: _
Coordinate System	WGS 1984 UTM Zone 30N

Overall, the large mammal diversity and density were low. Signs of anthropogenic activities were recorded on all transects, which were evenly spread out across the IEL. Mostly common species that are resilient to hunting and habitat degradation were encountered, such as the Maxwell's duiker (*Philantomba maxwellii*). During interviews, local people mentioned that many species had disappeared from the area several years ago, such as the Endangered western red colobus (*Procolobus badius badius*).

It appears that large mammal populations already plummeted in the 70s after the construction of the hydroelectric dam, which flooded large parts of the forest in this area. One of the significant mammal populations remaining in the area that would deserve particular conservation attention is the Vulnerable hippopotamus which was found on the Kossou Lake. Only five individuals were seen, but their presence were reported all along the shores of the Kossou Lake, and therefore a viable population may remain that would be regionally important for the persistence of this species.

The details of the Large Mammals Baseline Study are contained in **Error! Reference source not found.**.

6.6.3.6 Small mammals

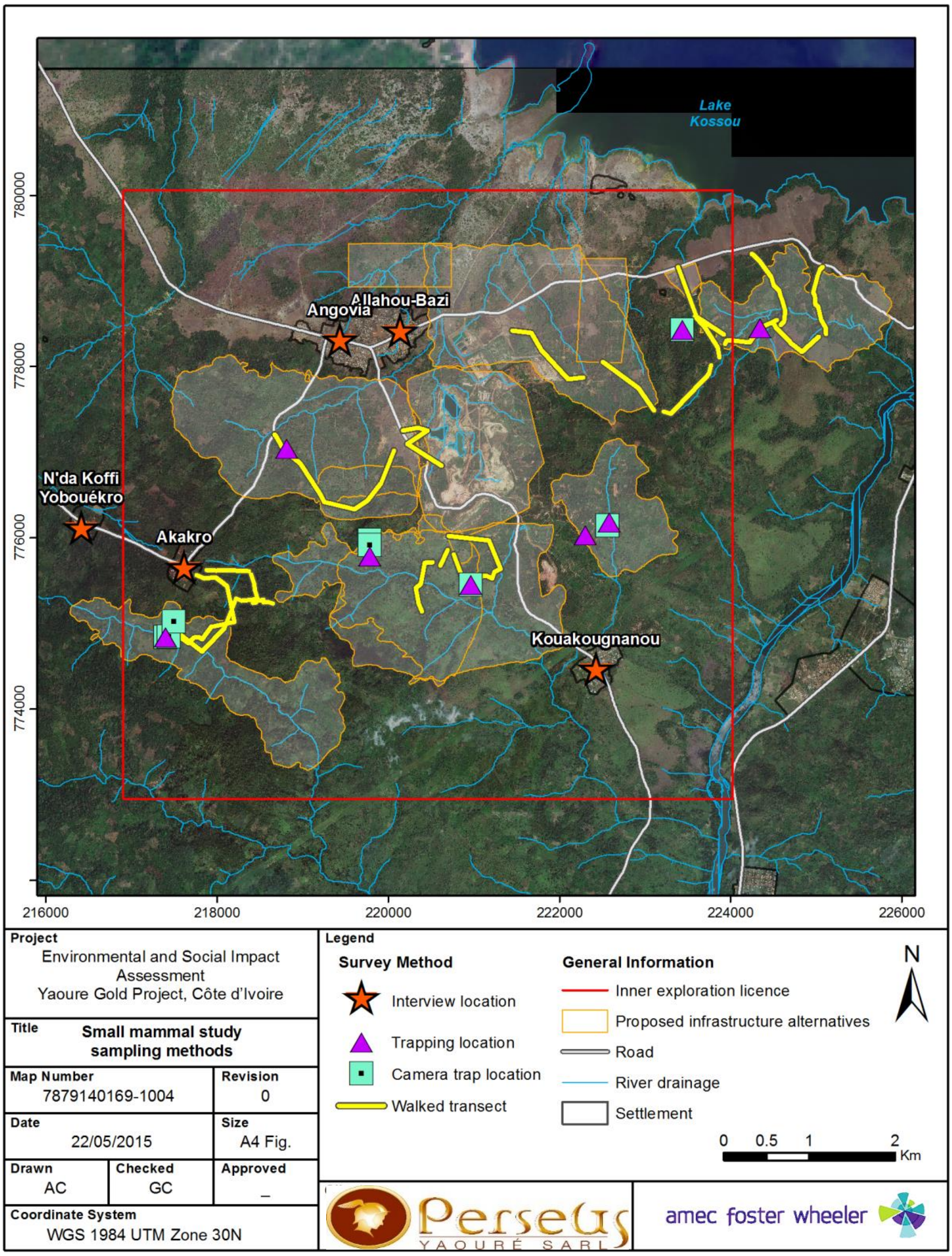
Description

Field surveys were carried out in the dry season to complete previous surveys that were conducted in the rainy season in 2007 (Tano et al., 2007). Four different methods were used to survey small mammals, which included micromammals and small carnivores (

Figure 6-19):

1) Interviews;
2) Reconnaissance walks;
3) Camera trapping; and
4) Pitfall trapping.

Figure 6-19 Sampling locations for small mammal surveys



Interviews were conducted in five villages. Local knowledge on small mammals was restricted to common species, and there was often confusion for species which harbour similar appearance or that possess several coat variation patterns (e.g. genets). Eight camera trapping and pitfall trapping locations were used. Reconnaissance walks covered a total distance of 17.7 km over the different infrastructure alternative locations.

Summary of main findings

Surveys confirmed the presence of eight species of small mammals, including four micromammal and four small carnivore species. Pitfall trapping was not successful, with only three species sampled. This might have been due to the season at which surveys were conducted, which was not optimal to capture micromammals.

None of the species recorded are threatened according to the IUCN Red List. However, some genet species were recorded from the area, but identification to the species level was often difficult. Indeed, the taxonomy of the genet is poorly understood and under constant reorganisation. Therefore, it is possible that threatened species of genet occur in the Project area.

The details of the Small Mammals Baseline Study are contained in **Error! Reference source not found.**.

6.6.4 Conclusion

Results from baseline biodiversity surveys emphasise the high level of habitat degradation and anthropogenic activities present in the Project area. This is reflected in the low fauna and flora diversity and density.

Overall, 24 globally threatened species were recorded from the area, belonging to five groups (Table 6-38). Four bird species, two amphibians, one plant species, one mammal and four fish species may trigger Critical Habitat, and are assessed in a separate document (**Error! Reference source not found.**).

Table 6-38 Summary of globally threatened species recorded for the project area

Family	Species	English name	IUCN status[1]	National Status[2]	RR[3]	EN[4]
BIRDS						
Psittacidae	*Psittacus timneh*	Timneh parrot	VU	-	no	no
Pycnonotidae	*Bleda eximius*	Green-tailed bristlebill	NT	-	yes	no
Sylviidae	*Bathmocercus cerviniventris*	Black-headed rufous warbler	NT	-	yes	no
Sturnidae	*Lamprotornis cupreocauda*	Copper-tailed glossy starling	NT	-	yes	no
Cisticolidae	*Apalis sharpii*	Sharpe's Apalis	LC	-	yes	no
REPTILES AND AMPHIBIANS						
Hyperoliidae	*Kassina schioetzi*	Schiøtz's running frog	LC	-	no	yes
Hyperoliidae	*Hyperolius* sp.	Reed frog	-	-	?	?
FLORA						
Combretaceae	*Terminalia ivorensis*	Black Afara	VU	-	no	no
Leguminosae	*Afzelia africana*	Afzelia	VU	-	no	no

Leguminosae	*Albizia ferruginea*	Albizia	VU	-	no	no
Loganiaceae	*Strychnos millepunctata*	-	VU	-	yes	yes
Meliaceae	*Entandrophragma* sp.	-	VU	-	no	no
Meliaceae	*Khaya grandifoliola*	Large-leaved Mahogany	VU	-	no	no
Sterculiaceae	*Nesogordonia papaverifera*	-	VU	-	no	no
Sterculiaceae	*Pterygota macrocarpa*	-	VU	-	no	no
FISH						
Cichlidae	*Tilapia busumana*		VU	-	no	no
Mormyridae	*Mormyrus subundulatus*	-	EN	-	no	no
Mormyridae	*Marcusenius furcidens*	-	NT	-	no	yes
Cichlidae	*Tilapia walteri*	-	NT	-	yes	yes
Mochokidae	*Synodontis bastiani*	-	LC	-	yes	yes
Mochokidae	*Synodontis punctifer*	-	LC	-	yes	yes
LARGE MAMMALS						
Bovidae	*Kobus k. kob*	Buffon's Kob	VU	-	no	no
Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	VU	-	no	no
Manidae	*Phataginus tricuspis*	White-Bellied Pangolin	VU	II	no	no
SMALL MAMMALS						
No globally threatened species identified						

1 IUCN Status: EN=Endangered; VU=Vulnerable; NT=Near Threatened; LC=Least Concern
2 National Status: I=Protected species; II= Partially protected species
3 RR=Restricted Range
4 EN=Endemic to Côte d'Ivoire

6.7 Landscape and Visual Impact

6.7.1 Methodology

The word 'visual' as used within this report is taken from the broadest meaning to include visual, scenic, aesthetic and amenity values represented by the built and natural environment, which in totality can be described as the area's sense of place.

An initial desktop analysis was undertaken through which the spatial digital terrain model (DTM) and project design data were analysed and manipulated using ArcGIS. This allowed gaining an understanding of the landscape, location of potential sensitive receptors, the scenic value and sense of place and an initial understanding of the absorption capacity of the landscape.

A photographic and field reconnaissance survey was undertaken from the 14th to the 17th of April 2015 of the site and the surrounding area, so that the receiving environment could be documented and adequately described. Data collected during the site visit allowed for a comprehensive description and valuation of the receiving environment, quality of the scenic resource, valuation of the sense of place, as well as the scope and extent of the proposed project.

Specific areas identified as sensitive receptors were visited in order to determine sensitivity and visual exposure of these receptors. These include the following villages:

- Allahou Bazi/Angovia;
- Akakro;
- Kouakoug Nanou; and
- Kossou.

The photography survey was undertaken using a digital Canon camera and 50 mm equivalent lens. Overlapping (50%) landscape format photographs were taken which are joined together using computer software to create a single panoramic image for each viewpoint. Details of the Landscape and Visual Baseline are provided in **Error! Reference source not found.**.

Data analysis and modelling: ArcGIS was used to determine the ZVI through terrain, topographical and land cover modelling of the various infrastructure components.

6.7.2 Landscape and visual baseline findings

6.7.2.1 General

The project area (including a 4 km buffer around the proposed infrastructure) is located mainly in hilly terrain with elevations between 160 masl and 550 masl. The forest-savannah mosaic landscape of the Yaoure exploration licence area is dominated by the Mount Yaoure hills in the centre and southern western section of the licence area. The steep slopes associated with Mount Yaoure dominate the south-western topographic section of the project area and support semi-deciduous forest. Plains present in the southern section constitute river valleys and narrow floodplains. The Bandama River flood plain enters the project area from the northeast and gradually descends to the south dominates the south-eastern section. The surrounding area is more open than the south-western section but relative steep slopes are still present.

In addition to the primary river, the Bandama, which flows southwards from the Kossou hydroelectric power station, there is a radial pattern of minor rivers and streams which drain the Mount Yaoure hills.

Asphalt roads are mainly limited to linking the major urban areas, including Daloa, Bouafle, Yamoussoukro. A large network of unsealed roads exists linking local villages. The condition of these roads varies between very poor to a relatively good standard.

Generally the land cover is composed of a mixture of semi-deciduous, bush/grassed savannah, agriculture practices, mining (conventional and artisanal) and villages. The level of transformation is high to moderate in the northern section of the project area primarily due to conventional and artisanal mining activities and agricultural practices.

The northern section of the study area is characterised by extensive mining and exploration activities. These include artisanal mining activities that have continued from historic times within the project area to commercial mining which is ongoing for more or less the past thirty years.

6.7.2.2 Sense of Place

Central to the concept of sense of place is that the landscape requires uniqueness and distinctiveness. The primary informant of these qualities is the spatial form and character of the natural landscape taken together with the cultural transformations and traditions associated with the historic use and habitation of the area. The study area is divided into three distinct areas (Northern, South-western and South-eastern sections, see Figure 6-20), each with its own visual character and sense of place. A ridge line forms a natural barrier between these three sections.

Northern section: The visual character of the northern section is dominated by previous conventional mining activities (existing pit and associated infrastructure), and the Allahou Bazi/Angovia residential settlement. Historic commercial mining, artisanal mining and associated activities provides the northern section with a distinct sense of place and forms an integral part of the landscape.

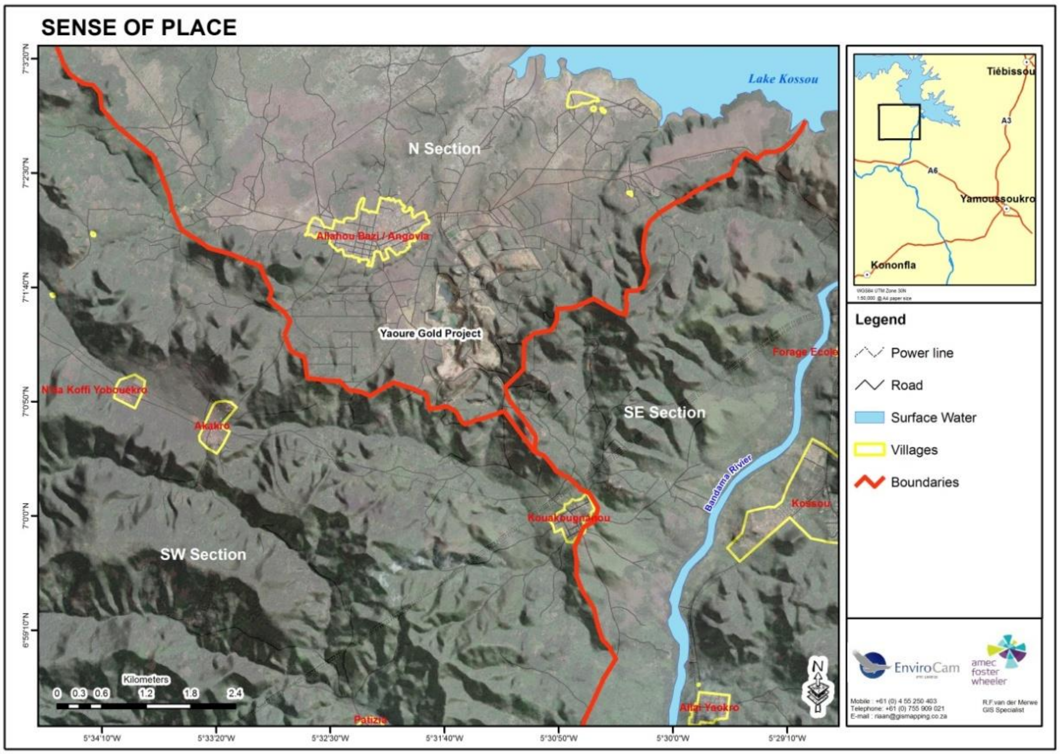
South-eastern Section: The area to the southeast of the proposed Yaoure Gold Project has a semi-rural character with a strong relationship with the village of Kossou and the Kossou hydroelectric power station with its associated power distribution network. The township of Kossou forms the centre of human activity within this section with various public services based within the township (schools, hospital, etc.). The Bandama River forms an integral part of this section and adds to the character of this section although recent unregulated mining has degraded the visual resource and sense of place considerably.

South-western Section: The south-western section has a rural character with a strong relationship with subsistence farming. Smaller villages are located within this section and are more associated with subsistence agricultural activities and to a lesser degree with mining activities. The two main villages (Akakro and Kouakougnanou) within this section are located within a valley and surrounded by hills and dense degraded and secondary forested areas.

A photographic documentation of the sense of place is provided in **Error! Reference source not found.**.

In summary, it has been established that the study area represents three distinct areas, each with its own visual character and sense of place. All sections have a relatively moderate to high sense of place dominated by either mining, semi-rural or agricultural activities. From the baseline information the area most vulnerable to a change in the sense of place is the northern section of the proposed Yaoure Gold Project due to the scale and extent of the proposed operations. This is enhanced due to the limited screening potential towards the north.

Figure 6-20 Relevant sections of sense-of-place characterisation



6.8 Air Quality

6.8.1 Survey Work

Baseline air quality monitoring was undertaken by Perseus between February and June 2015 around the proposed Yaoure Project. The monitoring scheme was devised by Amec Foster Wheeler so that the duration and type of monitoring undertaken at each location would provide sufficient data to inform assessment of the potential air quality effect(s) that the receptors are likely to experience during either (or all of) the construction, operational and closure phases of the proposed development.

Since the primary purpose of the monitoring is to inform the ESIA process, the monitoring was focused on characterising the air quality environment within settlements in the area immediately surrounding the development site. Monitoring locations were selected to ensure that the air quality environment of individual receptors likely to experience the worst case air quality effects from the development have been fully characterised. For example, at the village locations, measurement sites were chosen to represent the closest receptors to the mine.

The principal pollutants that are emitted from mining activities and the combustion of hydrocarbon fuels include the following:

- Nitrogen oxides (NO_X which comprises nitric oxide (NO) and nitrogen dioxide

(NO_2));

- Particulate Matter (PM_{10}: particles with an aerodynamic diameter of less than 10 micrometres (μm) and $PM_{2.5}$: particles with an aerodynamic diameter of less than 2.5 μm);
- Sulphur Dioxide (SO_2); and
- Deposited dust.

NO_2 and SO_2 concentrations were monitored using passive diffusion tubes which are simple, single-use sampling devices that absorb the pollutant directly from the ambient air and need no power supply. They tubes were exposed at the monitoring locations for a month, before being sent to a laboratory (SGS Ghana) for analysis. Duplicate tubes were deployed at each monitoring location. Three months of diffusion tube monitoring were undertaken.

PM_{10} and $PM_{2.5}$ concentrations were monitored using two E-Samplers of Met One Instruments Inc. fitted with appropriate inlets, provided by Enviro Technology. This instrument uses the light scattering properties of sampled air to determine the concentration of particulates in the sample. The instrument provides indicative particulate concentrations. Concentrations were monitored between 26 March 2015 and 04 June 2015.

Dust deposition rates were monitored using Frisbee Gauges, which gather dust in a collecting bowl. The deposited material is then washed into a collecting bottle to be sent to a laboratory (SGS Ghana) where the mass of solids collected is determined. Deposition rates are then calculated in $mg/m^2/day$. Three months of dust deposition monitoring were undertaken.

In terms of dust deposition, it is proposed to utilise the dust nuisance criteria developed by the Government of South Africa (RSA, 2005), reproduced below in Table 6-39, as these are considered to be appropriate in terms of the prevailing climate and existing sources and levels of dust deposition.

Table 6-39 Dust Deposition Criteria

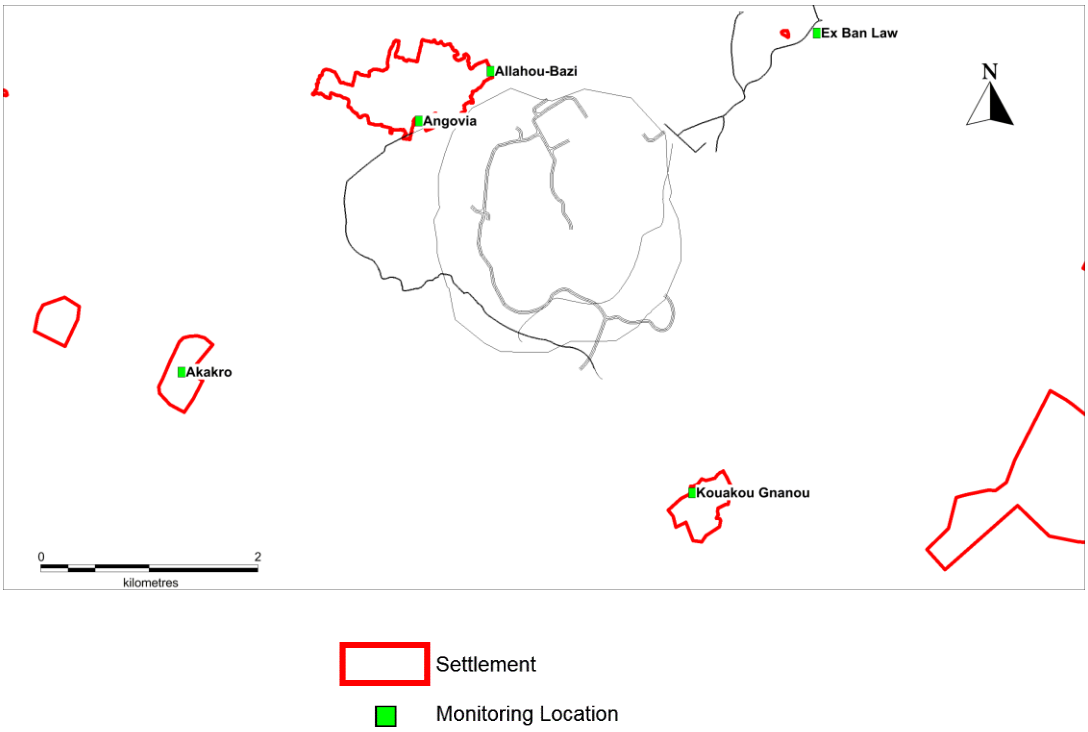
Dust Deposition Rate, $mg/m^2/day$	Effects
< 250	Slight
250 – 500	Moderate
500 – 1,200	Heavy
>1,200	Very Heavy

The selected monitoring points are shown in Table 6-40 and are also presented in below in Figure 6-21.

Table 6-40 Air Quality Monitoring Locations

Site ID	Location	Easting	Northing	Pollutants Monitored
1	Allahou-Bazi	220491	778519	NO_2, SO_2, Dust, PM_{10}, $PM_{2.5}$
2	Angovia	219830	778059	NO_2, SO_2, Dust
3	Kouakou Gnanou	222354	774623	NO_2, SO_2, Dust
4	Akakro	217638	775740	NO_2, SO_2, Dust
5	Ex Ban Law	223506	778869	NO_2, SO_2, Dust

Figure 6-21 Air Quality Monitoring Locations



Site 1 Allahou-Bazi is situated approximately 600 m to the north west of the open pit area and 300 m from the centre of Allahu-Bazi - Angovia. The instrument was set up near a path trafficked by on average approximately 50 pedestrians and 10 motorcycles per day, and is used mainly to collect water. In the vicinity of the measurement location were situated a blacksmiths workshop (approximately 140 m away); a mill (probably grain mill, approximately 15 m away); a mechanics workshop (approximately 180 m away); a small fabrication shop (approximately 146 m away and an artisanal miner's stone crusher (approximately 136 m away). In addition, two houses and a church were also located close by.

Site 2 Angovia is situated approximately 1100 m to the west of the Yaoure development site. The monitoring location was situated close to the village football ground near the main route through the village. There was a mechanical and blacksmiths workshops (less than 100 m away); a food market and a church (approximately 160 m away).

Site 3 Kouakougnanou is situated approximately 2100 m to the south of the Yaoure development site. The monitoring location was situated near a house and the primary school in the village. The monitoring point was located near to stone crushing activities (approximately 400 m away).

Site 4 Akakro - is situated approximately 3100 m to the south west of the Yaoure development site. The monitoring location was situated near the Akakro to Kouakougnanou road and approximately 30 m from the church.

Site 5 Ex-Banlaw is situated approximately 1700 m to the north of the Yaoure development site. Near to where the operations camp will be located.

6.8.2 Results

Air quality monitoring results averaged over the monitoring period are presented in Table 6-41. Full monthly results are shown in **Error! Reference source not found.**.

Table 6-41 Baseline Air Quality Monitoring Results

Site ID	Location	NO_2 conc. (µg/m^3)	SO_2 conc. (µg/m^3)	PM_{10} conc. (µg/m^3)	$PM_{2.5}$ conc. (µg/m^3)	Dust Deposition Rate (mg/m^2/day)
1	Allahou-Bazi	6.9	78.6	18.3	8.1	512.6
2	Angovia	5.9	74.9	-	-	437.5
3	Kouakou-gnanou	4.6	87.4	-	-	343.1
4	Akakro	4.4	71.7	-	-	283.0
5	Ex Banlaw	3.8	94.5	-	-	103.0

6.8.3 Discussion of Results

NO_2 – The average NO_2 concentration was below 7 µg/m^3 at all monitoring sites. Recorded concentrations are therefore well below the WHO annual mean Air Quality Guideline of 40 µg/m^3. The monitoring suggests that NO_2 concentrations in the area are low. These results are typical of a remote, rural environment, with a limited road network in the surrounding locale.

SO_2 – The average SO_2 concentration was below the WHO annual mean Air Quality Guideline of 50 µg/m^3 at all monitoring sites. These results should however be treated with caution as the mass of SO_2 recorded in the laboratory was below the limit of detection for the majority of samples (16 out of 30). The higher masses recorded in some samples appear to be anomalous results as duplicate tubes were deployed at each location and in some cases the results of one tube were below the limit of detection, whilst the other was above 50 µg/m^3. This indicates that the laboratory was experiencing difficulties in reliable analysis.

Particulate Matter – The average PM_{10} concentration recorded in Allahou-Bazi was 18.3 µg/m^3. This is below the WHO annual mean Air Quality Guideline of 20 µg/m^3.

Dust – The dust deposition rate was below the indicator for slight effects (250 mg/m^2/day) at Site 5, in the moderate effects range at sites 2, 3 and 4 and in the heavy effects category at site 1 in Allahou-Bazi. The high levels of dust deposition may result from the presence of a traditional grain mill in the vicinity. The contribution of other local sources of particulate emissions (e.g., suspension of particles from the dry, unpaved nearby road), is also likely to have contributed to the elevated dust levels observed during the baseline monitoring programme. The dust deposition values observed are, however, typical of other comparable sub-Saharan regions during the dry season.

6.9 Noise

6.9.1 Survey Work

Baseline noise monitoring was undertaken by 2D Consulting Afrique (see Section 0.1.2) in February 2015 around the proposed Yaoure Gold Mining Project. The monitoring scheme was devised by Amec Foster Wheeler so that the duration and type of monitoring undertaken at each location would provide sufficient data to inform assessment of the potential noise effect(s) that the receptor is likely to experience during either (or all of) the construction, operational and closure phases of the proposed development.

The proposed development site is located in the Bouaflé Prefecture of the Marahoué Region in Côte d'Ivoire and is surrounded by the following areas of habitation:

- Allahou-Bazi and Angovia, to the North;
- Akakro, to the Southwest;
- Kouakougnanou, to the South;
- Kossou, to the Southeast, and;
- A fishing hamlet known as Allahou port, to the Northeast.

Monitoring locations were selected to ensure that the noise environment of individual receptors likely to experience the worst case noise effects from the development have been fully characterised. For example, at the village locations, measurement sites were chosen to represent the closest receptors to the mine.

Since the primary purpose of the monitoring is to inform the ESIA process, the monitoring was focused on characterising the noise environment within settlements in the area immediately surrounding the development site. The monitoring points are shown in Table 6-42 and are also presented in Figure 6-22 below. Photographs of the monitoring locations are shown in **Error! Reference source not found.**.

Figure 6-22 Noise Monitoring Locations

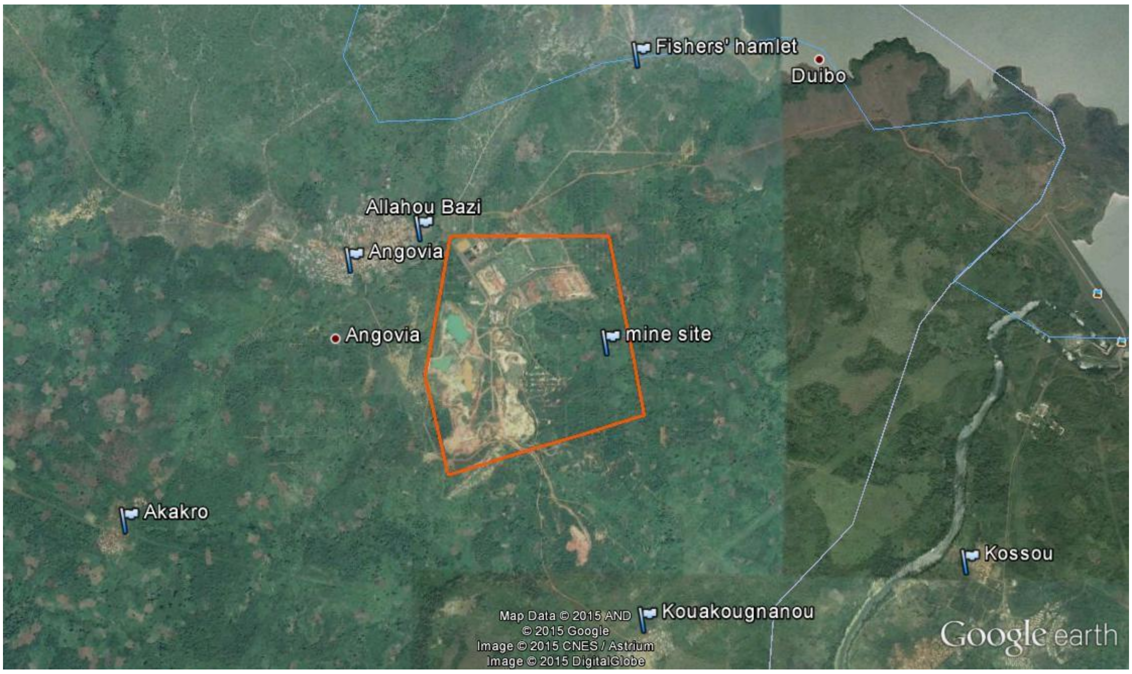


Table 6-42 Noise Monitoring Locations

Site ID	Description	Co-Ordinates	
		Latitude	**Longitude**
1	In the vicinity of Allahou-Bazi	7° 2'5,48"N	5°31'49,94"E
2	In the vicinity of Angovia	7° 1'55,82"N	5°32'11,04"E
3	On the mine site	7° 1'30,91"N	5°30'53,18"E
4	In the vicinity of Akakro	7° 0'37,91"N	5°33'17,75"E
5	In the vicinity of fishing hamlet	7° 2'58,08"N	5°30'43,61"E
6	In the vicinity of Kouakougnanou	7° 0'7,16"N	5°30'41,78"E
7	In the vicinity of Kossou	7° 0'24,26"N	5°29'2,88"E

Site 1 Allahou-Bazi is situated approximately 600 m to the north west of the open pit area and 300 m from the centre of Allahu-Bazi - Angovia. The instrument was set up near a path trafficked by on average approximately 50 pedestrians and 10 motorcycles per day, and is used mainly to collect water. In the vicinity of the measurement location were situated a blacksmiths workshop (approximately 140 m away); a mill (probably grain mill, approximately 200 m away); a mechanics workshop (approximately 180 m away); a small fabrication shop (approximately 146 m away and an artisanal miner's stone crusher (approximately 136 m away). In addition, 2. houses and a church were also located close by. The microphone position and an example of the type of activity

undertaken in the immediate vicinity are shown in **Error! Reference source not found.**.

Site 2 Angovia is situated approximately 1100 m to the west of the Yaoure development site. The monitoring location was situated close to the village football ground near the main route through the village. Sources of noise in the vicinity of the microphone position included a mechanical and blacksmiths workshops (less than 100m away); a food market and a church (approximately 160m away). The microphone position and an example of the type of activity undertaken in the immediate vicinity are shown in **Error! Reference source not found.**.

Site 3 Mine Site is situated within the mine site boundary overlooking most of the mine site area. The monitoring location was situated on a temporary road into the area. The main sources of noise were animal and birdsong with no anthropogenic sources of noise in the immediate area. Very little traffic used the temporary road other than vehicles used by the personnel undertaking the noise measurements. The microphone position is shown in **Error! Reference source not found.**.

Site 4 Akakro is situated approximately 3100 m to the south west of the Yaoure development site. The monitoring location was situated near the Akakro to Kouakougnanou road and approximately 30 m from the church. Sources of noise in the vicinity of the microphone position included the village water pump which also acts as a meeting point for people (approximately 75 m away) and a small roadside café/bar (approximately 110 m away). The microphone position and an example of the type of activity undertaken in the immediate vicinity are shown in **Error! Reference source not found.**.

Site 5 Allahou Port (Fishing Hamlet) is situated approximately 2800 m to the north of the Yaoure development site. The monitoring location was situated near the road trafficked by moto-taxis and trucks collecting water for use in the gold mines in Angovia. Other sources of noise in the vicinity of the microphone position include animals in the village. The microphone position and an example of the type of activity undertaken in the immediate vicinity are shown in **Error! Reference source not found.**.

Site 6 Kouakougnanou is situated approximately 2100 m to the south of the Yaoure development site. The monitoring location was situated between a house and the primary school in the village and other sources of noise in the vicinity of the microphone position included the village water pump and stone crushing activities (approximately 400 m away). The microphone position and an example of the type of activity undertaken in the immediate vicinity is shown in **Error! Reference source not found.**.

Site 7 Kossou is situated approximately 4300 m to the south east of the Yaoure development site. The monitoring location was situated in the compound of the school group Kossou 1 and 2 which was closed for the spring holidays (between 13th and 22nd February 2015). Sources of noise in the vicinity of the microphone position included children playing in the village and on the football pitch and road traffic nearby.

The microphone position and an example of the type of activity undertaken in the immediate vicinity are shown in **Error! Reference source not found.**.

The surveys, undertaken by personnel from 2D Consulting Afrique, generally consisted of unmanned measurements using 1 No. SVAN 959 Class 1 Sound Level Meter (SLM) with full environmental protection kit and 1 No. Cirrus Green Optimus Class 1 Sound Level Meter over three day periods at each location between Tuesday 3rd and Saturday 21st February 2015. Measurement positions were fine-tuned at each receptor based on the availability of suitable free-field locations, as well as security and access constraints.

For any given measurement, the following methodology was adopted:

- Day 1, installation of the noise measurement station followed by photographs of the location and notes on the main sources of noise in the immediate environs of the measurement point (for example: roads, noise of animals birds, humans, etc). Leave the instrument to log noise levels for 24 hours;
- Days 2 and 3, check on the monitoring instrumentation and more notes taken regarding nearby sources of noise; instrumentation left for a further 24-48 hours; and
- Day 4, dismantling of the instrumentation and recovery of noise data, travel to next noise monitoring location.

The above protocol was adopted until all monitoring points had been completed.

The monitoring methodology was based on the guidance within BS 7445 'Description and Measurement of Environmental Noise' (2003). The microphone was positioned between 1.2 m and 1.5 m above local ground level and away from reflective façades. The calibration of each SLM was checked using hand held calibrators at the start and end of the monitoring period, and no significant drift occurred. Battery levels also remained within acceptable limits throughout the monitoring period. Details of the monitoring equipment used are included in **Error! Reference source not found.**. Each meter was operated using a fast-time setting and A-weighting, and was set to continuously measure noise levels over consecutive 5-minute intervals.

Observations on audible noise sources were made during equipment deployment and retrieval.

6.9.2 Results

The meteorological data obtained during the surveys (2nd to 17th February 2015) indicate that no periods were identified where adverse weather conditions may have unduly influenced the noise monitoring, namely when wind speeds were in excess of 5 m/s (in accordance with BS4142:2014) or extended periods of heavy precipitation. In general, temperatures were between 22 - 40°C. Wind speeds were recorded at between 0-4.8 ms^{-1}, but averaging more like 1-3 ms^{-1}, mainly from the south east to north direction (but from all points of the compass at times during the surveys). There were no significant rainfall events recorded during the period for which data is available.

Average noise levels have been calculated for a selection of different time periods, each relating to the day, evening and night-time periods. These are summarised in Table 6-43 along with the relevant noise monitoring results. The full data set of results is presented graphically in **Error! Reference source not found.**.

Table 6-43 Noise Monitoring Results

Receptor Location	Measurement Periods (hrs)	$L_{Aeq, T}$	$L_{A90, T*}$	$L_{A10, T*}$	L_{Amax}	Comments
1. Allahou-Bazi (4th – 7th February 2015)	07:00-19:00	45.3	33.3	45.6	92.5	Noise sources include path activities, various workshops and people talking. More activity during evening period due to increase in general human activities
	19:00-22:00	46.6			72.9	
	22:00-07:00	40.3			78.7	
2. Angovia (8th – 11th February 2015)	17:00-19:00	49.4	40.2	50.8	86.9	Noise sources include road activities, various workshops, a food market and people talking. Slightly more activity during evening period due to increase in general human activities
	19:00-22:00	50.0			79.2	
	22:00-02:00	49.4			83.2	
3. Yaoure Site (9th – 12th February 2015)	07:00-19:00	44.8	33.8	44,2	92.5	Noise sources mainly include mainly animal and birdsong.
	19:00-22:00	44.4			84.4	
	22:00-07:00	43.9			76.6	
4. Akakro (12th – 15th February 2015)	07:00-19:00	56.4	38.9	49.3	92.8	Noise sources include road activities, village pump, a small café/bar and people talking. Slightly more activity during evening period due to increase in general human activities
	19:00-22:00	63.4			84.6	
	22:00-07:00	47.5			87.6	
5. Allahou Port (Fishing Hamlet) (13th – 16th February 2015)	07:00-19:00	61.8	36.0	47.3	100.9	Noise sources include road activities, animal sounds and people talking.
	19:00-22:00	52.4			95.8	
	22:00-07:00	47.0			96.9	
6. Kouakougnanou (16th – 19th February 2015)	07:00-19:00	49.0	35.5	49.5	87.1	Noise sources include road activities, animal/bird sounds, village pump and people talking.
	19:00-22:00	48.5			76.8	
	22:00-07:00	43.3			74.1	
7. Kossou (17th – 20th February 2015)	07:00-19:00	53.6	35.5	49.5	100.9	Noise sources include road activities, children playing, animal/bird
	19:00-22:00	49.1			91.9	

	22:00-07:00	47.6			102.2	sounds and people talking.
* The instrumentation used was only capable of measuring full 24 hour L_{A90} and L_{A10} parameters and therefore these results are average 24 hour readings						

6.9.3 Discussion of Results

Unfortunately the instrumentation utilised by 2D Consulting was not capable of logging L_n parameters in 5 minute periods and so a more detailed breakdown of the background noise levels is not available however this is not seen as a major omission since noise criteria in Côte d'Ivoire and as used by the IFC are single figure limits and therefore do not derive noise criteria directly from background noise levels. In addition, weather conditions during the entire survey period from 3rd to 20th February 2015 were generally dry, sunny and warm (24-40ºC) with wind speeds generally less than 5 ms^{-1}. Based on the meteorological data available, it is not considered that the prevailing weather conditions significantly affected the measured noise results.

Site 1 Allahou-Bazi – Measured noise levels are in the region of 45-46 dB $L_{Aeq, 12h}$ during the day rising to 46-47 dB $L_{Aeq, 3h}$ during the evening period. This slight increase in noise level is probably directly linked to the increase in social activity during the evening period within the area, when people are out and about. The corresponding average $L_{A90, 24hr}$ are in the region of 33-34 dB(A), obviously affected by lower levels during the night.

Night-time noise levels are lower at 40-41 dB $L_{Aeq, 9h}$ which appears to be due to the decrease in general activity around the village but is still influenced by sources in the vicinity such as insect/animal and very occasional traffic noise.

Site 2 Angovia – Measured noise levels are in the region of 49-50 dB $L_{Aeq, 12h}$ during the day with similar levels of about 50 dB $L_{Aeq, 3h}$ during the evening period. The increase in social activity during the evening period when more people are out and about in the vicinity of the monitoring location does not therefore appear to significantly affect noise levels. The corresponding average $L_{A90, 24hr}$ are in the region of 40-41 dB(A) once again affected by lower levels during the night.

Night-time noise levels are about the same as those measured during the daytime period at 49-50 dB $L_{Aeq, 9h}$ indicating that the main sources of noise may now be bird, insect and animal noise rather than human activities.

Site 3 Yaoure Mine Site – Measured noise levels are in the region of 44-45 dB $L_{Aeq, 12h}$ during the day and 44-45 dB $L_{Aeq, 3h}$ during the evening period. This is due to the relatively isolated nature of the monitoring location well away from areas of human activity. The corresponding average $L_{A90, 24hr}$ are in the region of 33-34 dB(A) again affected by lower levels during the night.

Night-time noise levels were measured at the mine site, which indicate levels of 44 dB $L_{Aeq, 9h}$ indicating that the main sources of night-time noise are similar to those during the rest of the day with no sources of anthropogenic noise (see time history for Location 3 in **Error! Reference source not found.**).

Site 4 Akakro – Measured noise levels are in the region of 56-57 dB $L_{Aeq, 12h}$ during the day rising to 63-64 dB $L_{Aeq, 3h}$ during the evening period. This increase in noise is probably directly linked to the increase in social activity during the evening period possibly linked to the nearby café/bar. The corresponding average $L_{A90, 24hr}$ are in the region of 38-39 dB(A) which are likely to be affected by lower levels during the night.

Night-time noise levels are lower at 47-48 dB $L_{Aeq, 9h}$ which appears to be due to the decrease in general activity around the area but is still influenced by sources in the vicinity such as insect/animal activities.

Site 5 Allahou Port (Fishing Hamlet) – Measured noise levels are in the region of 61-62 dB $L_{Aeq, 12h}$ during the day falling to about 52-53 dB $L_{Aeq, 3h}$ during the evening period. The noise climate during the day is influenced by traffic on the nearby road carrying tanker and other lorries to and from the Angovia gold mines. This traffic evidently eases during the evening and night-time periods when there is a corresponding increase in bird, animal and insect activity during the evening period in the vicinity of the proposed settlement. The time history for Location 5 in **Error! Reference source not found.** illustrates the influence of the passing traffic in terms of L_{Amax}s. The corresponding average $L_{A90, 24h}$ are in the region of 36 dB(A) which are likely to be affected by lower levels during the night.

Night-time noise levels were measured at this location, which indicate levels of about 47 dB $L_{Aeq, 9h}$, again indicating that the main sources of night-time noise may now be bird, animal and insect noise from the local environs.

Site 6 Kouakougnanou – Measured noise levels are in the region of 49 dB $L_{Aeq, 12h}$ during the day and 48-49 dB $L_{Aeq, 3h}$ during the evening period. The increase in social activity during the evening period when more people are out and about in the vicinity of the monitoring location does not therefore appear to significantly affect noise levels. The corresponding average $L_{A90, 24h}$ are in the region of 35-36 dB(A) again affected by lower levels during the night.

Night-time noise levels are lower at 43-44 dB $L_{Aeq, 9h}$ which appears to be due to the decrease in general activity around the village but may still be influenced by sources in the vicinity such as insect/animal and very occasional traffic noise.

Site 7 Kossou – Measured noise levels are in the region of 53-54 dB $L_{Aeq, 12h}$ during the day and 49-50 dB $L_{Aeq, 3h}$ during the evening period. Therefore, the increase in social activity during the evening period when more people are out and about in the vicinity of the monitoring location once again does not appear to have significantly affected measured noise levels. The corresponding average $L_{A90, 24h}$ are in the region of 35-36 dB(A) which will again be affected by much lower levels during the night.

Night-time noise levels are lower at 47-48 dB $L_{Aeq,\ 9h}$ which appears to be due to the decrease in general activity around the village but may still be influenced by sources in the vicinity such as insect/animal and very occasional traffic noise.

The measured results appear to be typical of the noise environments observed in each of the locations monitored. The daytime noise levels would generally be comparable to levels found in semi-rural and semi-urban areas in the UK. Some of the evening noise levels are obviously influenced by the increased social and animal/insect activity in the locality during that particular period of the day and are therefore not really comparable to typical levels in the UK. However, most of the night-time noise levels also appear to be mainly influenced by non-anthropogenic, natural sources such as birds, insects and animals.

In summary, at the existing villages of Allahou-Bazi, Angovia, Akakro, Allahou Port, Kouakougnanou and Kossou (Receptors 1-2 and 4-7), noise levels measured were all in the region of 45-62 dB $L_{Aeq,\ T}$. In general, evening noise levels were slightly higher, equal to or lower than daytime noise levels depending upon the level of social activity and traffic movements within the populated areas during this period. In addition, night-time noise levels were generally lower than those measured during the daytime period which indicates the influence of more steady natural noise sources in the surrounding areas such as the birds, insects and animals. At the location within the mine site itself (Receptor 3), measured noise levels were all in the region of 44-45 dB $L_{Aeq,\ T}$ whatever the time of day or night. This was due to the lack of anthropogenic noise sources in the area where noise levels were more influenced by natural occurring noise from birds, animals and insects.

6.10 Traffic and Transportation

6.10.1 Methodology

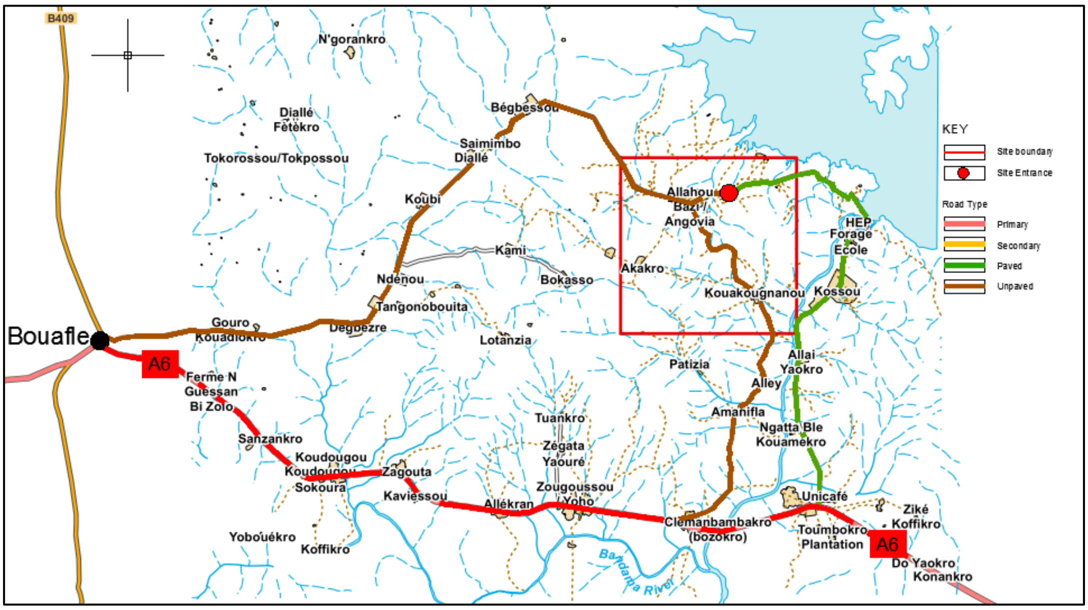
An assessment of the strategic and local highway network has been undertaken to identify the most suitable access route to the site. The assessment was carried out over a period of two days (26 – 27 November 2014) and involved a video survey of the A6, between Toumbokro and Bouaflé and of the three local access roads which connect the site with the A6/Bouaflé, as identified in Figure 6-23. During the site inspection in November 2014, observations of traffic behaviour, its interaction within local settlements and the physical condition of the local highway network were recorded in both a written format and using GPS video capture technology. In addition to the above, traffic data was collected by local enumerators in order to understand key trends and modal splits in terms of numbers of vehicles, pedestrian, etc, facilitate a quantitative assessment of highway capacity, and identify the peak traffic flow demands on the local network.

The study area primarily consists of the immediate local highways that provide connections from the site to the settlements of Bouafle, Toumbokro and Bonzi, all of which are served by the strategic A6 highway. The A6 is a regional highway that ultimately links Duekoue in the far west of the country with Yamoussoukro to the east.

In addition to the local highway network, some consideration has been given to the national strategic network that will be utilised during the life cycle of the mining operation to deliver materials and goods not readily available within the local area from the port cities of Abidjan and San-Pedro. The former is linked to site via the A3 and the A6, and the latter via the San Pedro – Betia Road, the A5 and the A6.

The highway network referenced within this chapter is illustrated within Figure 6-23.

Figure 6-23 Traffic Study Area



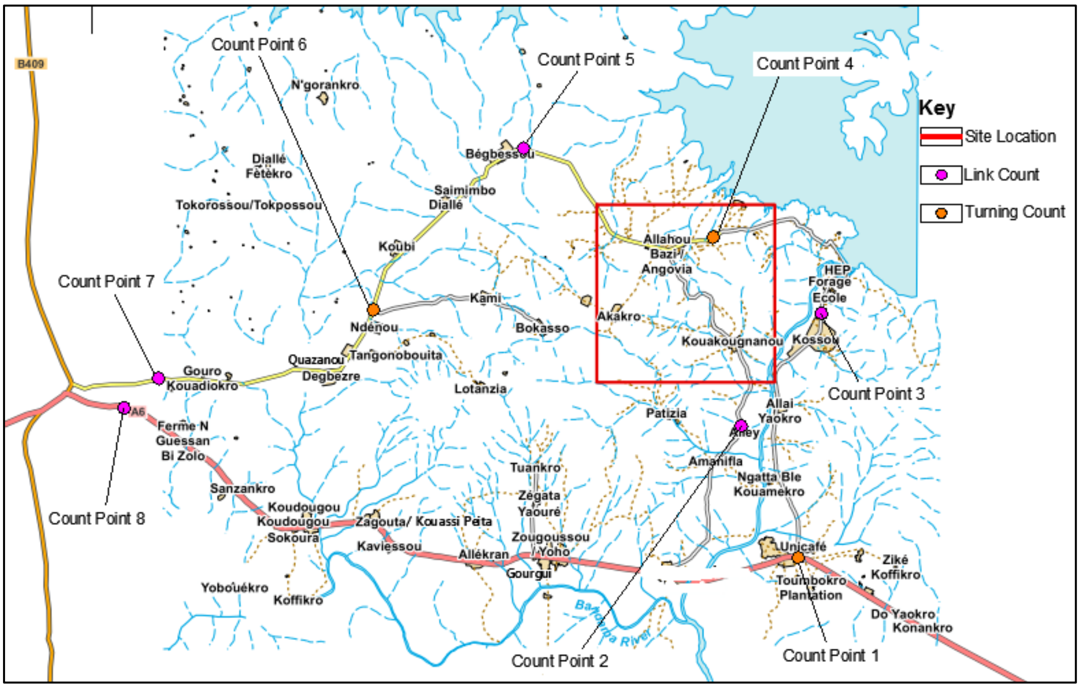
A review of the available traffic accident data has been undertaken to assess and identify any current accident trends within the local area. The data has been provided by the Department for Infrastructure and Transport (DIT).

The accident data review comprises a qualitative assessment of the information provided and an assessment of the causation factors and likelihood of future accidents occurring as a result of the proposed Project.

Fully classified traffic surveys have been undertaken at eight locations, six of which are on local roads and two are on the strategic A6. The local roads comprise the three available access roads that could be used to serve the site as illustrated within Figure 6-23. The count locations are illustrated within Figure 6-30. Further details on the survey methodology are contained in **Error! Reference source not found.**.

In order to assess the impact of the Project-related traffic on the highway network, there needs to be establishment of the capacity of the roads in terms of traffic volumes. With regards to capacity, consideration has been given to UK guidance contained within Design Manual for Roads and Bridges (DMRB) TA 46/97: 'Traffic Flow Ranges for Use in the Assessment of New Rural Roads'. This guidance has been utilised in the absence of any local or international guidance on the assessment of highway link capacity in the Cote d'Ivoire.

Figure 6-30 Count Point Locations



Whilst it is appreciated that the guidance may not be entirely applicable, given the differences in highway design criteria between the UK and Cote d'Ivoire, the factors that influence capacity such as the proportion of Heavy Goods Vehicle (HGV) traffic, carriageway width, road use (i.e. urban/rural), and speed limit are fundamentally universal. It is therefore considered that the traffic flow values presented within DMRB provide a reasonable indication of capacity for the strategic and surfaced highway network. It is acknowledged that local unsurfaced roads are unlikely to achieve the levels of capacity identified but given their status they are unlikely to be highly trafficked nor attractive to a high level of vehicles, with the exception of motorcycles. Therefore whilst comment will be made on daily flows, a thorough review of traffic flow capacity in unmade roads is not considered appropriate.

6.10.2 Strategic and Local Highway Review

The strategic highways (i.e., all classified highways of regional/national importance) considered within this assessment provide reasonable, partly high quality links between Abidjan and the local site area, despite the presence of pot holes along the A6.

The local highway network (i.e., all unclassified roads which serve local settlements) is largely comprised of unmade and poorly maintained laterite tracks, which serve the surrounding local villages and are considered to be incapable of accommodating a high-level of traffic.

The exception to this is the purpose built highway that routes along the eastern side of the Bandama River between the A6 and the dam. This road provides a reasonable quality asphalt surfaced carriageway, capable of accommodating two-way traffic flow. Sections of the road are in need of maintenance and it is also noted that the quality of the road between the dam and the site access is relatively poor.

6.10.3 Traffic Accident Data Review

A review of the available traffic accident data has been undertaken to assess and identify any current accident trends within the local area. The data has been provided by the Department for Infrastructure and Transport (DIT). The data received was for 2012 and 2013. The accident raw data are included in the Traffic Study (**Error! Reference source not found.**).

From the review of the available traffic accident data it has been concluded that the recorded accidents are attributable to driver/pedestrian error and not to a defect in the design or maintenance of the highway network.

6.10.4 Traffic Survey Results

The traffic survey results have been analysed in order to identify key trends and patterns in travel behaviour during a typical week and day during the cocoa harvest season. The results for the November/December 2014 and April 2015 surveys have been analysed separately in order to ensure any seasonal shifts in travel behaviour are identified.

For count points located on unmade tracks within rural area, the proportion of vehicular traffic has been consistently low, with high proportions of pedestrians and two-wheelers. This pattern is endemic to the nature and purpose of these roads, which exists to provide local means of access for neighbouring villages.

Paved roads have higher proportions of vehicular traffic, although it is noted that pedestrians and two-wheelers still form a significant proportion of movements at each location, with the exception of count point 1.

The weekly profiles show flow fluctuation on a daily basis, with the exception of count point 1, although it is noted that some consistency is present for one survey and not the other at the remaining count points.

The daily profiles show fluctuations for count points 1, 3, 6 and 7, with more typical daily profiles observed at count points 2, 4, 5 and 8, which is attributed to more commuter based travel behaviour.

It is also noted that all movements terminate around 18:30, which corresponds with information provided by the client regarding the avoidance of night time travel, due to the lack of street lighting and an increase in criminal activity.

No exceedance of the capacity thresholds were identified and it was established that the provision of turning lane at count point 1 was unnecessary. However, the high proportion of pedestrians recorded around the mine site, at count points 2, 4 and 5, will need to be considered when managing traffic movements to and from the site.

Note: There are no railway lines in the wider Project area.

6.11 Socio-Economic Baseline

6.11.1 Introduction

The present Section, the Socio-Economic Baseline Study (SEBS), constitutes a baseline inventory and analysis of social, cultural and economic conditions in the areas of influence of the Project, as outlined in Section 0.

6.11.1.1 Scope of Work

The overall objective of this Section is to describe the social, socio-economic and cultural context of the different areas affected by the PERSEUS Project, as well as to scope and identify potential socio-economic issues, risks, and constraints that could affect project design and development. The emphasis is therefore on compiling and analysing the primary and secondary data collected and the analysis of identified issues. The scope of the SEBS includes:

- Historical and political context;
- Circumstances of women and children;
- Socio-economic conditions and needs;
- Level of infrastructure and needs;
- Land ownership, land rights and land use;
- Economic sectors: main activities, sources of income and active population;
- Vulnerable target groups and level of poverty level; and
- Cultural context and social organisation of different ethnic groups.

6.11.1.2 Structure and Organisation of the Socio-Economic Baseline

The volume includes five sections in addition to the present introduction:

Section 6.11.2 (Methodology) presents the sub-division of the Project's social study area into three levels, the area of regional influence, the area of local indirect influence, and the area of local direct influence. It then summarises the sources of quantitative and qualitative data used to document social, cultural and economic conditions; and, the sampling methods, approach and tools used in the field research programme.

Section 6.11.3 (Rural Land Management in the Project Area) describes the ways in which rural and agricultural land is governed in the Study Area, whether according to statutory or customary law, the rights of local people, including women, to land and land access in rural areas, and the several means by which rural or agricultural land may be expropriated, sold, or otherwise transferred to third parties. This Section therefore complements the summary of the legal and regulatory framework in Section 0 of this Report.

Section 6.11.4 (Socio-Demographic Profile of the Study Area) summarises the analysis of village and household-level data collected in the project area of influence and presents a profile of key population and household characteristics. It also tackles social development in the Study Area in terms of the levels of education attained by the population, school attendance figures, and access to education services and facilities; and, living conditions, including housing, access to water and sanitation, and energy use. The Section reviews additional specific issues, such as the non-income dimensions of poverty and gender relations.

Section 6.11.5 (Livelihood Systems) presents an analysis of the principal livelihood systems found within the project area of influence. It is based primarily on focus groups, interviews, and other village and household-level data collected in the villages. It considers the local context in order to understand the roles and contributions of subsistence agriculture, cash cropping, animal husbandry, artisanal mining, fishing, and other non-agricultural economic activities, as well as local and regional marketing networks and other supports to livelihood systems.

6.11.2 Methodology

The methodology used for the SEBS synthesises quantitative and qualitative information to develop profiles and identify key issues and indicators related to the social, economic and cultural conditions in the local Study Area.

6.11.2.1 General Approach

The general approach to the SEBS was to follow a participatory process in collaboration with government authorities, community leaders, local populations and household members. The preparation and realisation of the study was a dynamic process encompassing work undertaken over nearly a year, from June 2014 to April 2015.

There were three major methods and tools used to collect the required information:

- Literature review, including compilation and analysis of primary and secondary data obtained from previous studies, government, and other sources;

- Field research programme, including household surveys, village consultations and household focus groups, key informant interviews, and walk-over surveys in affected communities; and
- Development of a social baseline database.

6.11.2.2 Socio-Economic Area of Study

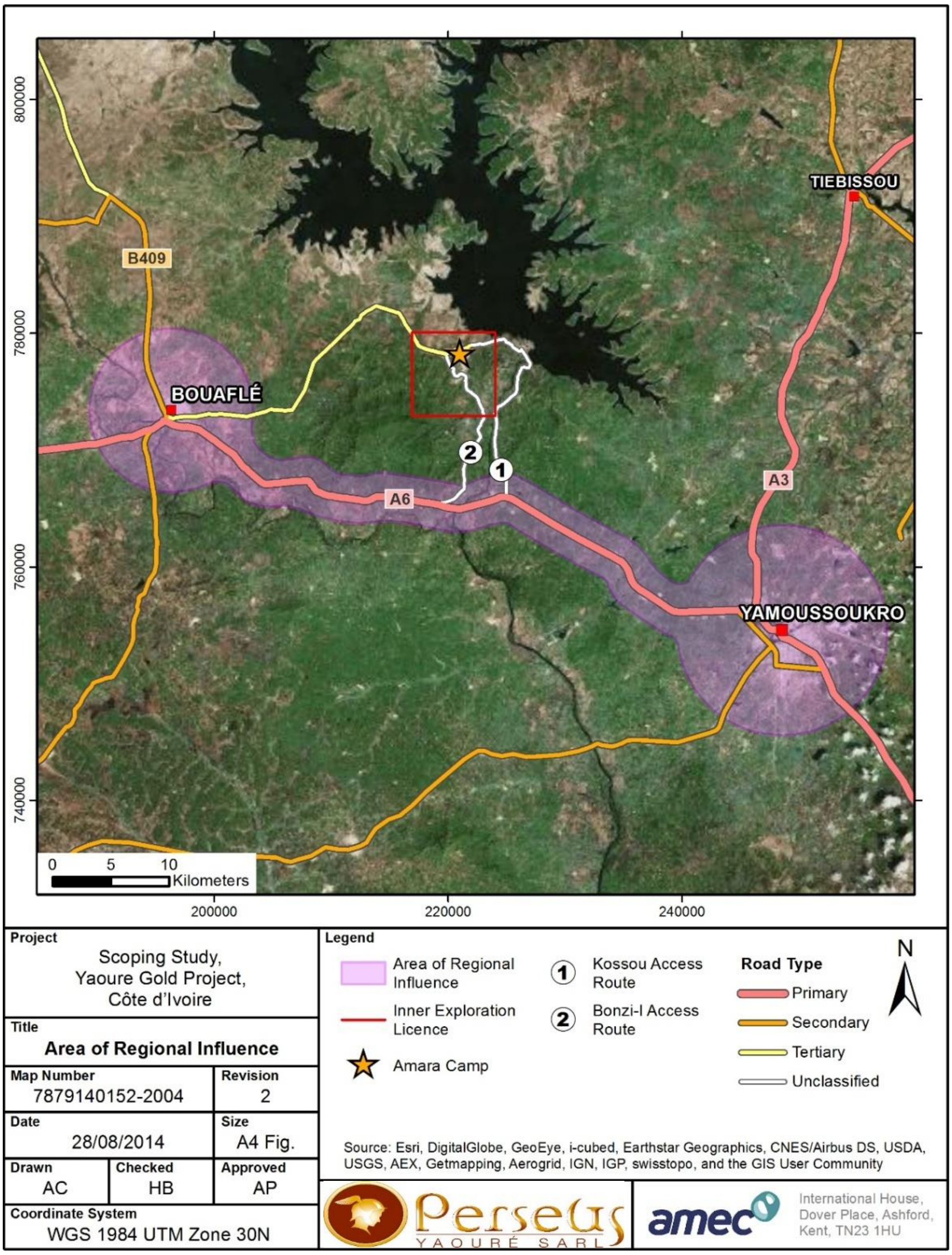
The SEBS focuses primarily on the social, cultural, and economic conditions and issues within the local Study Area, based on criteria for levels of potential impact associated with the mine project. It also takes into consideration social and economic conditions at regional and national levels in order to establish a relevant context within which to understand the local conditions. This Section identifies the larger regional area of influence (ARI) but focuses on the identified direct and indirect local areas of influence. It identifies the selected priority villages and provides a general description of the communities.

Area of Regional Influence

Located roughly 240 kilometres north-west of Abidjan, the area of regional influence encompasses the regions of Belier and the region of Marahoué located between the urban centres of Yamoussoukro and Bouaflé (see

Figure 6-24). The availability of relevant data and information at the regional level was important to the preparation of the SEBS as a means to establish a context within which to understand conditions in the Project area and to complement existing data. For example, data collected for the 2014 Côte d'Ivoire Census, which focuses its analysis on administrative regions, was particularly useful when available. The prefectural administration is often the source of important data regarding education and health care services. The analysis of agricultural production and marketing systems also links priority villages to a wider regional context.

Figure 6-24 Area of Regional Influence



The Area of Local Indirect Influence

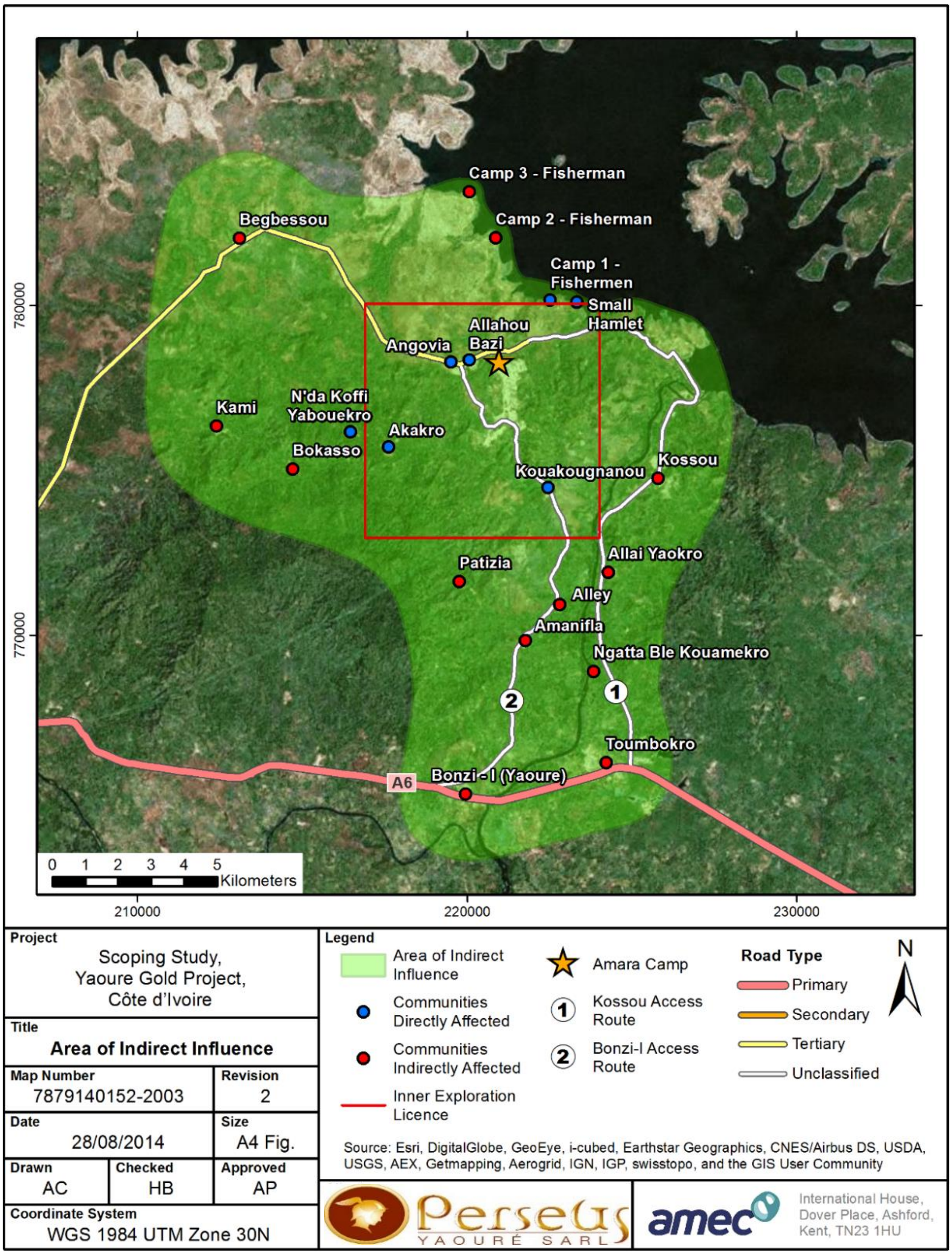
The Area of Local Indirect Influence (ALII) is centred on the northern portion of the ARI. On a north-south axis, the area extends from Lake Kossou in the north to the Yamoussoukro - Bouaflé road in the south. More specifically, it includes portions of the Sub-Prefectures of Kossou (Belier Region), Begbessou and Bouaflé (Marahoué Region). The Bandama River forms a natural border between the two regions (see Figure 6-25).

The Area of Local Indirect Influence of the Project is the area in which the socio-economic environment is likely to be indirectly affected by Project activities and in which the Company will likely have to apply a moderate effort towards social performance management. Table 6-44 below provides the list of communities that comprise the ALII.

Table 6-44 Communities in the Area of Local Indirect Influence

Community	Sub-Prefecture	Prefecture	Region	Observations
Allai Yaokro	Kossou	Yamoussoukro	Belier	
Alley	Bouaflé	Bouaflé	Maraouhé	
Amanifla	Bouaflé	Bouaflé	Marahoué	Hamlet Of Patizia
Begbessou	Begbessou	Bouaflé	Marahoué	
Bokasso	Begbessou	Bouaflé	Marahoué	
Bozi	Bouaflé	Bouaflé	Marahoué	
Cf2	Boufalé	Bouaflé	Marahoué	Hamlet Of Allahou Bazi
Cf3	Bouaflé	Bouaflé	Marahoué	Hamlet Of Allahou Bazi
Kami	Begbessou	Bouaflé	Marahoué	
Kossou	Kossou	Yamoussoukro	Belier	
Patizia	Bouaflé	Bouaflé	Marahoué	
Ngatta Ble Kouamekro	Kossou	Yamoussoukro	Belier	
Toumboukro	Yamoussoukro	Yamoussoukro	Belier	

Figure 6-252 Area of Local Indirect Influence



The Area of Local Direct Influence

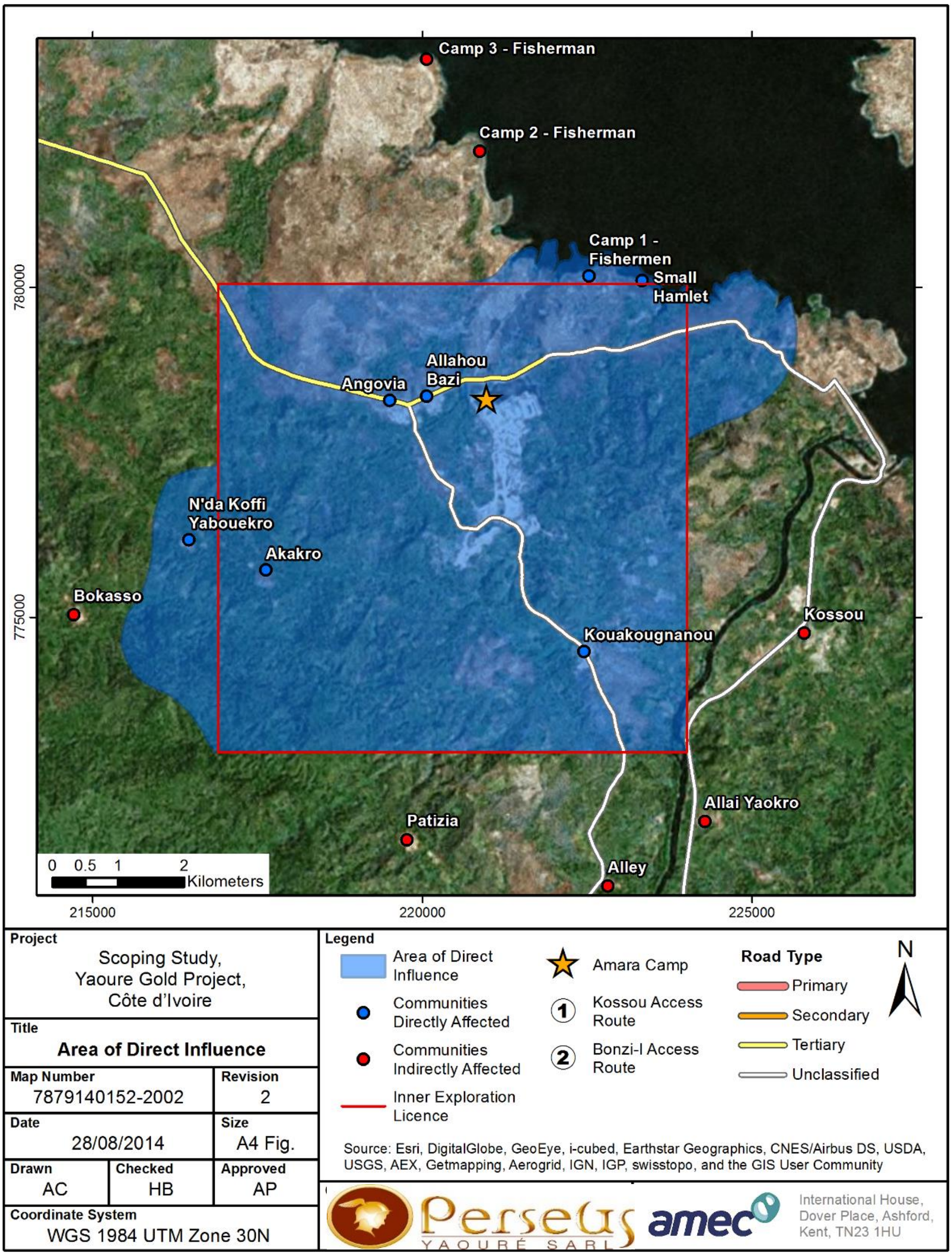
The Area of Local Direct Influence (ALDI) is located within a perimeter of 50 square kilometres within the ALII (Figure 6-26).

This area served as the focus for baseline data collection activities, including extensive primary research (household surveys, key informant interviews, etc.) during the ESIA process. Most impacts and Project facilities are nestled within the ALDI, which falls entirely under the jurisdiction of the Bouaflé Sub-Prefecture, as shown in Table 6-45

Table 6-45 Communities in the Area of Local Direct Influence

Community	Sub-prefecture	Prefecture	Region	Observations
Akakro	Bouaflé	Bouaflé	Maraouhé	
Allahou Bazi	Bouaflé	Bouaflé	Maraouhé	
Angovia	Bouaflé	Bouaflé	Marahoué	
CF1	Bouaflé	Bouaflé	Maraouhé	Hamlet of Allahou Bazi
CF1 (Hamlet)	Bouaflé	Bouaflé	Maraouhé	Idem
Kouakou Gnanou	Bouaflé	Bouaflé	Marahoué	
N'Da Koffi Yobouekro	Boufalé	Bouaflé	Marahoué	

Figure 6-26 Area of Local Direct Influence



Determination of Study Area Through Analysis of Level of Impacts

This SEBS includes the re-assessment of the levels of impact anticipated by the Project as a means to establish the types of engagement that will be required to occur with the different communities located near the mine facilities. The levels of impact are defined in terms of the potential adverse impacts the Project can or will cause in the various communities. Impacts are categorised in descending order of risk, from the highest risk (impact level = 5) to the lowest (impact level = 1) (see Table 6-46).

Table 6-46 Categorisation of impacts in the Study Area (Source rePlan, 2015)

Level of impacts	Type of impacts
5	• Important influx of job seekers; • Large-scale economic resettlement, possible physical resettlement; • Visible effects on local recruitment and market transactions; • Changes in social behaviour and traditions; • Land speculation and loss of traditional land management procedures; • High inflation attributable to project presence; • High level of interactions with village authorities and communities; and • Other impacts linked to in-migration such as stress on public services (clean drinking water, schools, waste management, health services). All 5 villages in the ALDI belong to this Category 5 of socio-economic impacts: • Akakro; • Allahou Bazi (including hamlets); • Angovia; • Kouakougnanou; and • N'Da Koffi Yobouekro.
4	• Village on local access road to base, regular passage of project vehicles and staff; • Limited economic resettlement; • Limited influx of workers; • Impact on artisanal mining business; • Likely moderate benefits on employment opportunities and market transactions; • Moderate inflation attributable to project presence; • Clear increase in traffic compared to pre-project situation; • Regular level of interactions with village authorities and communities; and • Occurrence of temporary environmental degradation linked to the project. 4 villages in the ALII belong to this Category 4 of socio-economic impacts: In the Marahoué Region • Patizia; • Amanifla; • Alley; and In the Belier Region • Kossou.
3	• A few minor / transient negative impacts (noise, traffic, dust); • Villages that belong to an administrative district including villages of impact level 4 and 5 and that are less than 4 km from the concession limits;

	• Increase in local production of building materials (sand and gravel) for sale to the project, causing some environmental damage; • Increase in the activity of the local market (indirectly linked to the presence of the project); • Rare to occasional interactions with village authorities and communities; and • Situated on a river from the project activity area in the Simandou watershed. 2 villages in the ALII belong to this Category 3 of socio-economic impacts: In the Belier Region • Allai Yaokro; and • Ngatta Ble Kouamekro.
2	• Slight increase in traffic on main road (some vehicles and trucks linked to the project); • Limited increase in the activity of the local market (indirectly linked to the presence of the project); and • Occasional interactions with village authorities and communities. 3 villages in the ALII belong to this Category 2 of socio-economic impacts: In the Begbessou Sub-Prefecture of the Marahoué Region • Bokasso; • Kami; and • Begbessou
1	• Village in a sub-prefecture that is adjacent to the concession or to ancillary sites; • Village with high resilient capacities; • Aware of the project but no significant impact. 2 villages in the ALII belong to this category 1 of socio-economic impacts: • Bozi I (Yaoré); and • Toumbokro.

6.11.2.3 Literature Review

The literature review encompasses a wide range of information, including primary data collected in and reported by previous studies conducted by Perseus Mining (previously, Cluff Gold) and its consultants, and secondary data gathered in literature reviews and meetings with public and private-sector stakeholders at the national, regional and local levels.

Overview of Previous Studies

Perseus Mining has conducted several field investigations as well as various social and environmental studies for the purposes of the Yaoure Project. Previous studies were carried out in order to obtain a better understanding of the social organisation and socio-economic conditions of local communities and the receiving environment. The studies were reviewed and information was integrated and referenced into the SEBS, where relevant. The main sources include:

- The ESIA report for the Cluff Gold Mining Project of 2006/2007;
- The PEA Report (Preliminary Environmental Assessment) of April 2014;

- The Scoping Report of the Yaoure Project of August 2014;
- The Terms of Reference for the Social Impact Assessment of August 2014; and
- The PERSEUS ASM Survey of November 2014.

Review of Secondary Data

Secondary data includes data that have already been collected by individuals or agencies for purposes other than those of the Yaoure Project. A significant amount was obtained from national and regional sources (Household Income and Expenditure Survey, Population Census, Health and Education, Government Agriculture Offices, etc.) and from specific surveys and studies conducted by various agencies (UN, WB/IDA, AFD, EU, USAID, World Education, etc.).

The Government of Côte d'Ivoire requested that the Institut National de la Statistique (INS) conduct a new population census in 2014 (RGHP - recensement general de la population et de l'habitat) and update figures taken in the last official census of 1998. This SEBS is based on figures from the census of 2014, where available (the complete publication of figures is due before elections scheduled for fall, 2015), and on projections extrapolated from 1998 figures.

Other Sources of Information

Other sources of information were accessed primarily by Internet search. This research has provided complementary information, particularly at the national and regional levels, on topics such as social development indicators, land tenure systems, and livelihood systems.

6.11.2.4 Field Research Programme

Overview

The field research programme encompassed village consultations, household surveys, key informant interviews, focus group discussions and other participatory data collection tools and was intended to provide current data and information on demographic, social, and economic conditions in the ALDI and the villages of the ALII identified as priority level 4 or 5 in Section 6.11.2.2. The programme was carried out in two phases. Initial scoping fieldwork was conducted in June-July 2014 (see Table 6-47). Household surveys and detailed qualitative research was carried out in February-March 2015 to ensure complete sets of village and household data for the identified rural priority villages (see Section 6.11.2.2).

Table 6-47 Methodological Proposal after Scoping Phase (Source rePlan, 2015)

Categories of information required	TOOLS					
	Household survey	Focus Groups	Key Informant Interviews	Participant observation	Community Mapping	GIS mapping
General household demographic information	X					
Human capital	X					
Community and family health	X	X	X			
Education	X		X			
Training and skills profiles	X	X				
Food security	X	X	X		X	
Use of health and education infrastructure	X	X			X	
Water and sanitation	X			X	X	X
Social Capital						
Identification of key stakeholders and relationships	X	X	X			
Community organizations (COs) and NGOs	X	X	X			
Decision making systems		X	X			
Local and regional political structure & structure			X			
History, cultural values, traditions and beliefs (religion)	X	X	X		X	
Economic Capital						
Artisanal mining activities	X	X		X	X	X
Identification of alternative livelihood options		X	X			
Agriculture, cattle farming and fishing	X	X	X			
Employment & employment expectations	X	X	X			
Income & Expenditures	X		X			
Business revenues and costs	X		X			
Types of businesses	X	X	X			
Financial infrastructure and literacy	X	X			X	X
Natural Capital						
Ecological Services	X	X			X	X
Land use and ownership	X	X	X		X	X
Importance of sacred forests and sites		X			X	X
Physical Capital						
Housing and accomodations	X	X		X		
Hard infrastructure (roads, bridges, electricity, etc)			X	X	X	X
Soft infrastructure (schools, health centers, etc)			X	X	X	X
Settlement patterns		X	X	X		X
Cross-sectional topics						
Gender roles		X	X			
Human Rights and Security	X	X				
Vulnerability		X	X	X		
Perception of the project	X		X			

The following sections provide more detailed information about the design and execution of the village consultations and household surveys and identify the limitations of the programme. Figure 6-25 shows the Project area of influence, including all villages, priority and non-priority, included in the SEBS field research programme, and their corresponding level of impact.

<u>Survey of Priority Villages by Level of Impact</u>

The field research programme was designed to explore the detailed social, cultural and economic conditions of communities living in priority level 4 and 5 villages. Table 6-48 presents the type of data collection for social research conducted for each of the priority categories established in Section 6.11.2.2.

Table 6-48 Field Research Programme by Level of Impact (Source rePlan, 2015)

Level of impact	Village Survey	Household Surveys	Focus Groups	Key Informant Interviews	Walk Over Surveys	Site Inspections
Priority 5	Y	Y	Y	Y	Y	Y
Priority 4	Y	Y	Y/N	Y/N	N	Y
Priority 3	N	N	N	N	N	Y
Priority 2	N	N	N	N	N	Y
Priority 1	N	N	N	N	N	Y

Village Consultations

Selection of Villages

A total of 8 village consultations were conducted as a consequence of the delimitation of the Study Area presented in Section 6.11.2.2. All 8 villages indicated as priority level 4 and 5 were selected for the primary research component of the study in order to obtain a clear understanding of social conditions in the area with highest level of impact. The selected villages are presented in Table 6-49 below.

Table 6-49 Communities where village consultations were conducted (Source rePlan, 2015)

Prefecture	Village
Belier Region » Kossou Sub-Prefecture	Kossou
Marahoué Region » Bouaflé Sub-Prefecture	Akakro
Marahoué Region » Bouaflé Sub-Prefecture	Allahou Bazi (including hamlets)
Marahoué Region » Bouaflé Sub-Prefecture	Alley
Marahoué Region » Bouaflé Sub-Prefecture	Angovia
Marahoué Region » Bouaflé Sub-Prefecture	Kouakougnanou
Marahoué Region » Bouaflé Sub-Prefecture	N'Da Koffi Yobouekro
Marahoué Region » Bouaflé Sub-Prefecture	Patizia

Village Consultation Guide

The objective of village consultations was to obtain key information about each village. The consultation guide (**Error! Reference source not found.**A) included the following themes and questions:

- Village origin, ethnicities, founding and landowning lineages and demographic characteristics;
- Village land boundaries, relations between village settlement and hamlets and land disputes (intra and inter-village);
- Livelihood systems: landholdings, livestock, dwelling types, equipment and durable goods;

- Methods of customary agricultural production and livestock farming, main agricultural production activities, significant stockbreeders and types of pastoralist activities;
- Presence of associations and interest groups (youth, women and others);
- Markets and marketing networks; and
- Village infrastructure and community facilities, including schools, health care facilities, markets, water supply.

Village Consultation Process

Community meetings were organised in each of the selected villages with targeted key stakeholders, such as appointed and elected local authorities, traditional leaders, and / or active or prominent individuals within the community. Other members of the community often attended community meetings, and, in some instances, participated in discussions.

The length of the consultations varied between one and three hours depending on the educational level of the participants and the proximity of the village to the Project site, which proved to be important factors that determined the level of public interest in the Project.

Household Surveys

Household surveys were conducted in February and March 2015, in a total of 8 villages. Field teams interviewed a total of 380 households. Villages where household surveys were conducted as part of the field research programme are identified in Table 6-50.

Table 6-50 Communities where household surveys were conducted (Source rePlan, 2015)

Prefecture	Village	# Household Surveys
Belier Region » Kossou Sub-Prefecture	Kossou	60
Marahoué Region » Bouaflé Sub-Prefecture	Akakro	35
Marahoué Region » Bouaflé Sub-Prefecture	Allahou Bazi (including hamlets)	80
Marahoué Region » Bouaflé Sub-Prefecture	Alley	20
Marahoué Region » Bouaflé Sub-Prefecture	Angovia	70
Marahoué Region » Bouaflé Sub-Prefecture	Kouakougnanou	35
Marahoué Region » Bouaflé Sub-Prefecture	N'Da Koffi Yobouekro	20
Marahoué Region » Bouaflé Sub-Prefecture	Patizia	60

Definition of Household

For the purposes of the SEBS, a household is defined as "a unit of residence, of production and of consumption." This definition includes all the people who live together on a daily basis within the same concession, producing, cultivating and eating together and sharing a common budget. A household may include "foreigners," if accepted by the household head, as well as permanent farm workers. Temporarily absent family members, such as individuals who left the community to work or study, were also considered within the survey.

Selection of Villages

As with the village consultations, the distribution of villages where household surveys were conducted reflects the methodology described in the "Survey of Priority Villages by Level of Impact" segment in Section 6.11.2.4.

Sampling of Households

Using the most recent available data on village population, a sample size was established for each surveyed village to ensure, at a 90% confidence level, that the sampling error would be approximately 10% or less. Within each village, households were selected in consultation with the local leadership to ensure representation of (i) household sizes, (ii) agricultural production and livestock raising activities, and (iii) members of the founding lineage and other key lineages.

Household Survey Questionnaire

A standard survey questionnaire was prepared to collect data from all surveyed households. The questionnaire (**Error! Reference source not found.**B) was divided into several categories of information, namely:

- Household demographic data: origin and composition of each household and its members, including age, sex, relationship to household head, ethnicity, religion and residency;
- Economic activities: the primary and secondary economic activities of male and female household members, including information on where these activities are carried out and the revenues they generate;
- Education level: the level of education achieved by male and female household members, including information on current school attendance at the primary and secondary levels;
- Living conditions: the tenure and type of housing occupied by the household, along with data on durable goods, access to water, sanitation, energy sources, and distance to and usage of schools and health care facilities;
- Land tenure and access: the tenure, type, and area of land holdings of male and female household members, including how land was acquired, formal and customarily-recognised rights;

- Land uses: the types of land and methods of cultivating or using land, for male and female members of the household;
- Agricultural labour: the roles and responsibilities of men, women and children, including agricultural labourers, for different aspects of the household agricultural economy;
- Agricultural production: food and cash crops cultivated by members of the household by season and type of land, including yields, use for household consumption and/or sale, and revenues, as well as responsible household members;
- Livestock production: types of animals raised by male and female household members, roles and responsibilities for raising animals, use of animal products for household consumption and/or sale, revenues, and conflicts among herders and between herders and farmers;
- Other economic activities and sources of revenues: summary of non-agricultural economic activities and revenues for male and female members of households, by degree of importance to overall household income;
- Household revenues and expenditures: a summary of household revenues from all sources and key expenditures;
- Access to livelihood support services: the participation of household members in community-based, user, or other associations, and access to formal and informal credit; and
- Household needs and priorities: summary of the most important needs and priorities for different household members according to sex and age.

Household Survey Process

For the initial phase of the household surveys, the research team was composed of social specialists and social surveyors, most of whom were recruited through the Department of Sociology at the University of Cocody (Abidjan), who worked under the direction of the principal sociologist. The surveys were contracted to 2D Consulting, a local firm, and conducted by Baoulé or Yaoure-speaking surveyors of Côte d'Ivoire working under the direction of a senior sociologist from Côte d'Ivoire and rePlan SIA project manager. The household surveys were generally conducted in each village following village consultations.

Key Informant Interviews and Focus Group Discussions

Key informant interviews (KIIs) and focus group discussions (FGDs) were conducted in February and March 2015, in a total of 7 villages. Field teams interviewed a total of 36 individual people and conducted 17 focus groups. The villages where KIIs and FDGs were conducted as part of the field research programme are identified in Table 6-51.

Table 6-51 Key Informant Interviews and Focus Group Discussion in the Study Area (Source rePlan, 2015)

Prefecture	Village	Target Group / Individual	Type of Activity
Belier Region » Kossou Sub-Prefecture	Kossou	Farmers (Agriculture, Eco-system Services)	Focus Group
		Youth	Focus Group
		Women	Focus Group
		CIE – Kossou Dam	Interviews (2)
Marahoué Region » Bouaflé Sub-Prefecture	Akakro	Farmers (Agriculture, Eco-system Services)	Focus Group
		Youth	Focus Group
		Women	Focus Group
		Teachers / School Staff	Interviews (6)
Marahoué Region » Bouaflé Sub-Prefecture	Allahou Bazi (including hamlets)	Immigrants	Focus Group
		Fishermen	Focus Group
		ASM Operators	Interviews (7)
		Transporters (Taxi and Moto Taxi Drivers)	Interviews (2)
Marahoué Region » Bouaflé Sub-Prefecture	Alley	Mutuelle de Developpement – Assistance Group	Interview (5)
Marahoué Region » Bouaflé Sub-Prefecture	Angovia	Farmers (Agriculture, Eco-system Services)	Focus Group
		Youth	Focus Group
		Women	Focus Group
		ASM Operators	Interviews (3)
		Petty Traders	Interviews (2)
		Clinic Staff	Interviews (4)
		Teachers / School Staff	Interviews (1)
Marahoué Region » Bouaflé Sub-Prefecture	Kouakougnanou	Farmers (Agriculture, Eco-system Services)	Focus Group
		Youth	Focus Group
		Women	Focus Group
		ASM Operators	Interviews (3)
		Teachers / School Staff	Interviews (1)
Marahoué Region » Bouaflé Sub-Prefecture	Patizia	Farmers (Agriculture, Eco-system Services)	Focus Group
		Youth	Focus Group
		Women	Focus Group

Definition of KIIs and FGDs

A key informant interview is a qualitative, in-depth interview with people who understand their community and how it works. The purpose of key informant interviews is to collect information from a wide range of people - including community leaders, professionals, and residents - who have first-hand knowledge about the community. A focus group discussion is defined as a group of interacting individuals having some common interest or characteristics, brought together by a moderator who uses the group and its interaction as a way to gain information about a specific, or focus,issue.

Selection of Villages

The distribution of villages where field surveys were conducted reflects the methodology described in the "Survey of Priority Villages by Level of Impact" segment in Section 6.11.2.4. For the sake of this study, some villages were grouped together on the assumption that neighbouring communities share a large number of services and community challenges. Therefore Angovia and Allahou Bazi were considered as a single target group. Similarly, Akakro and N'Da Koffi Yobuekro, and Patizia and Alley, were considered together. Kossou and Kouakougnanou were considered separately.

Sampling of Target Groups and Individuals

Within each group of villages, target individuals or groups were selected in consultation with local leadership to ensure (i) coverage of strategic areas identified during the scoping phase (see Table 6-47); (ii) availability of key informants and of first-hand information; and, (iii) relevance of issues in the target area.

KII and FGD Questionnaires

The SIA team prepared a track with standardised questions to collect data for each type of targeted individual or focus group. Thus, the range of questions surveyors asked of the interviewees was diverse and tailored specifically to the interviewees. Questionnaires were designed to explore the economic, social, physical, natural and human characteristics of each study area:

- Economic Capital: artisanal mining activities, agriculture, cattle farming and fishing, employment and sources of revenues, food security, and poverty;

- Social Capital: identification of key stakeholders and stakeholder engagement, decision making systems, NGOs, CSOs and other village association groups;

- Physical Capital: hard and soft infrastructure (roads, bridges, schools, hospitals), housing and accommodation;

- Human Capital: education, community and family health, training and professional skills; and

- Natural Capital: Eco-system services (hunting, fishing, gathering fruits and medical herbs, collecting wood and building materials).

Survey Process

The research team that conducted the KIIs and FGDs was composed of social specialists who worked under the direction of the principal sociologist. This qualitative research was contracted to 2D Consulting, a local firm, and conducted by specialists from Côte d'Ivoire – all Baoulé or Yaoure speaking - working under the direction of a senior rePlan sociologist and SIA project manager.

Other Participatory Data Collection Tools

The SIA team complemented the field research activities outlined above with other data collection tools, which were used on an occasional basis according to project needs. These tools include:

Walkover Surveys

This method consists of walking through the project footprint or selected zones of the Study Area to identify potential socio-economically sensitive areas and validate preliminary findings based on an analysis of satellite imagery.

Community Mapping

This intensively participatory activity aims primarily to generate a clear understanding of community priorities as well as helping to identify community needs. Community maps will support subsequent efforts to identify impacts.

Participant Observation

This method provides explicit verification of issues raised through other qualitative or quantitative methods.

Spatial Mapping

This method supports the development of community and infrastructure profiles within the region through geo-referenced thematic maps, which normally results in easier identification of more relevant and Project-specific social management strategies.

Limitations of Field Research Programme

When considering the results of the field research programme, it is necessary to keep in mind several constraints and limitations that affected the village consultations, and, in particular, the data collection and analysis of household surveys.

Dynamics of Village Consultations

Village consultations were designed to collect data and other information from a small number of individuals, specifically the village leadership. However, as often happens in this region, the meeting took place in an open area in the village and many community members were present.

The development of the Yaoure Project has been ongoing for a number of years. While there are mining activities elsewhere in Côte d'Ivoire, it represents an important project for the local region and for the country. People have high expectations and a range of concerns related to the Project, particularly with respect to employment and induced in-migration. As a consequence, throughout the village consultations there were animated exchanges not only between the field team and the local leadership, but also with and among other people living in the community. The high level of interest and interaction made it challenging to ensure that consultations addressed the topics identified and to record accurately what said.

Length of Household Surveys

The household survey questionnaire is extensive and requires time. As a consequence, the level of concentration of most respondents varied over the course of the interview. As their concentration waned, people's responses became less precise and the quality of the information provided tended to decline. The challenge for the field team was to obtain as much valuable information as possible within a relatively short time frame (e.g., a maximum of 90 minutes).

Consistency and Accuracy of Responses

Notwithstanding the impacts of the length of the household survey, the results obtained are remarkably robust. In general people consistently provided a range of information for most if not all of the questionnaire sections. At the same time, however, many people found it difficult to provide precise answers to some questions. This was particularly true in the case of questions that required quantitative assessments and/or measurements. The field team reported that this lack of accuracy is linked to low literacy rates within the Study Area.

Agricultural Income Data

Lack of accuracy in responses was particularly acute with respect to household income obtained from the sale of agricultural produce. Most respondents were able to provide reasonably accurate information on non-agricultural income, but were unable to do the same for income derived from selling or trading their agricultural products. The reason for this is inherent in how people market agricultural products. Harvests of cash crops such as coffee, cocoa, bananas and other fruit are staggered throughout the year. Food crops and garden produce are also seasonal. Similarly, most people tend to sell agricultural produce in small amounts staggered throughout the year. This pattern is a response to livelihood strategies focus on generating cash as needed, and it tends to apply to the sale of cash crops as well as the sale of surpluses of food crops and garden produce. Therefore, cash income from agricultural production is accumulated in small amounts over the year and most people do not keep a record of this income (more information on livelihoods strategies and income is provided in Section 6.11.5).

Fieldwork Validation

Preliminary findings from the survey process were disclosed to the 2nd ESIA Committee Meeting in May 2015. Representatives from the regional delegations of the central ministries, together with the representatives of the Prefectures, Sub-Prefectures and Villages of the Study Area were presented with the preliminary outcome of the SEBS analysis and were asked to validate the accuracy of the information provided. More information about this and other consultation meetings can be found in the Section on Stakeholder Engagement in the ESIA (Section 5).

6.11.3 Rural Land Management in the Project Area

From our field surveys, it appears that in the area of local direct influence, rural land management is mainly conducted according to customary law. As such, the Yaoure ethnic sub-group, as the first occupants of the area, are considered to be the main customary landowners.

The land in the Study Area consists of perennial crop plantations (cocoa and coffee mainly), fallow land, forests and rivers. These lands belong to village communities, and, within these communities, to lineages, or families. References to tribal or village land are becoming less common, however, tribes and villages remain significant realities in the area. As a result of various factors, including population growth, socio-political changes, and extensive development of certain cash crops, collective land ownership has made way for family land ownership. That is, land originally intended as an inalienable common good is managed by family and community leaders and passes from generation to generation.

Principles

Land management in the Yaoure project area is carried out according to various principles and practices:

- Women cannot inherit land. Women's access to land takes place only under the authority of her husband or the man on whom she depends, often when widowed. Women tend to grow annual crops that can be used for consumption, with any surplus sold in local markets;

- Young people are granted access to the land of their families. Traditionally, young members of the family work on agricultural land but let senior members of the family (head of the lineage or household) decide how to allocate agricultural produce (family consumption or sale);

- Migrants may not own or purchase land in the Study Area. However, many came to the area, attracted by the cocoa plantations, and secured access to land following the practice of sharing agreements or long-term rentals, as described above; and

- Activities such as artisanal mining compete with farming for the use of agricultural land. Artisanal miners, often non-natives, secure temporary land access for gold exploitation through cash transactions with the landowners.

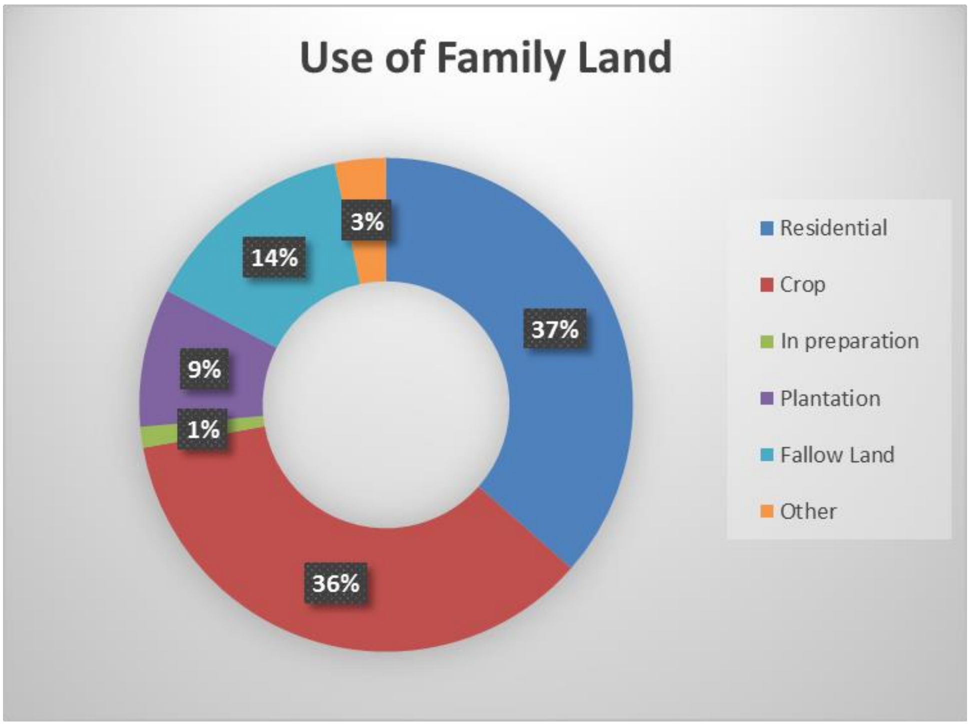
Use of Family Land

Landowners in the Study Area use their land to build residential structures, grow crops and plantations, and take advantage of local eco-system services, such as wood, wild fruit, and medicinal herbs. Residential plots account for 37% of total land parcels owned by resident households (see Figure 6-27). The relative majority of owned parcels are used for agricultural purposes (36% annual crops, 9% plantations, 1% in preparation). Fallow land is mostly used as family reserve land (old fallow) or to implement a crop rotation system (young fallow).

Land plot sizes can vary considerably as a function of their position and use. From the socio-economic surveys we can estimate the following:

- An average plot of residential parcels is 0.09 hectares;
- An average agricultural plot is 2.4 hectares; and
- An average fallow land plot is 5.1 hectares.

Figure 6-27 Type of Uses of Family Lands



On average, it is estimated that each household of the Study Area has access to 2.9 land parcels (of which at least one is residential). This corresponds to a property of 1.8 hectares of customarily-owned land per household. Most households (75%) claim land rights on between 2 and 4 land parcels (see Figure 6-28). In most cases, communities claim customary ownership of the land (90% of the parcels), but there are cases of land access based on other types of ownership or use rights, including: donation, property title, sharing, and rental contracts. Figure 6-296 illustrates the incidence of each form of land right in the Study Area.

Figure 6-28 Number of Land Parcels per Household (Source rePlan, 2015)

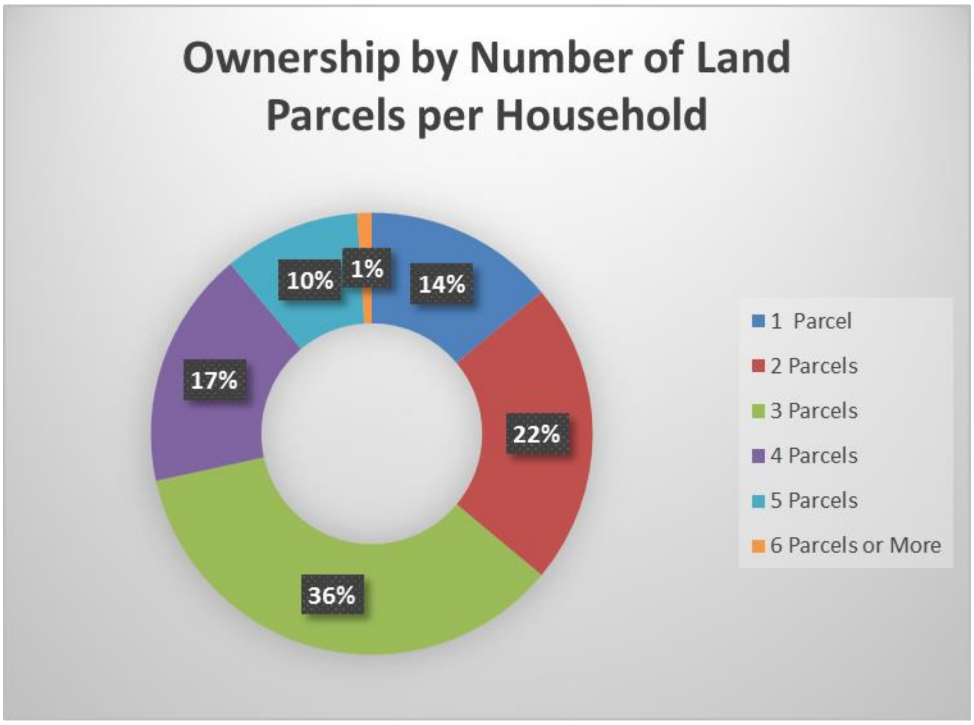
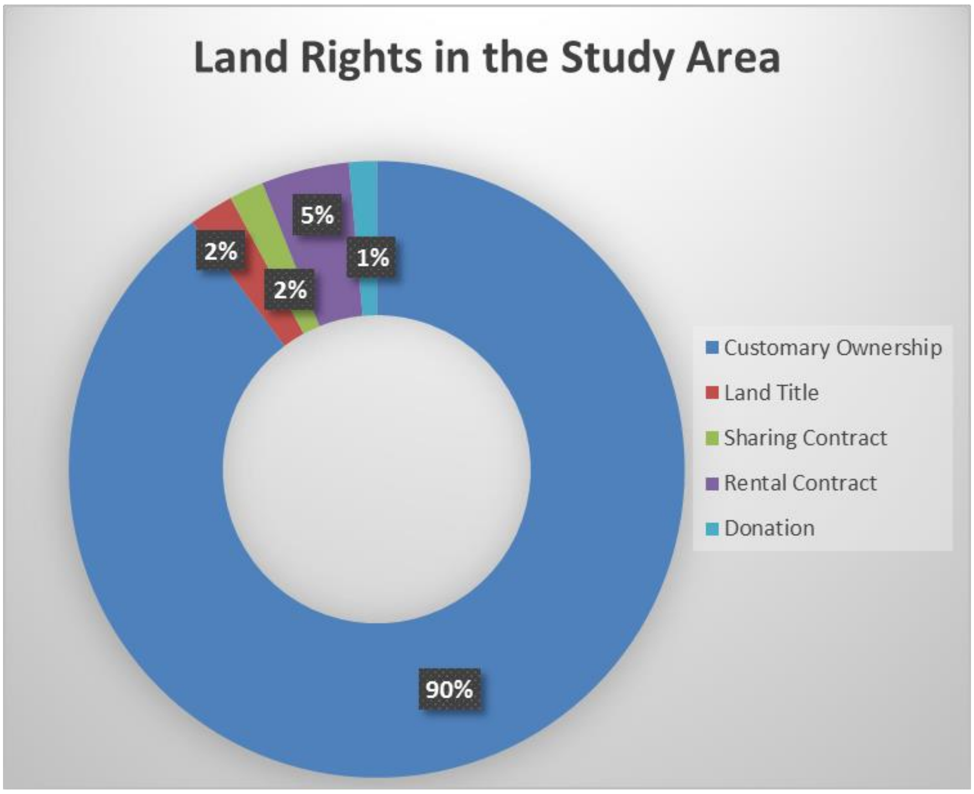


Figure 6-29 Land Rights in the Study Area (Source rePlan, 2015)



6.11.4 Socio-Demographic Profile of the Study Area

This Section focuses on communities located within the Study Area that are expected to experience level 4 and 5 socioeconomic impacts as a result of the Project. The principal data sources used to profile level 4 and 5 communities include village consultations, KIIs, FGDs, and, more importantly, household surveys. Regional and national data were used to establish the context for the socio-demographic conditions, when available. The Housing Censuses conducted by the National Statistics Bureau in 1998 and most recently in 2014, are the main sources of national and regional data.

6.11.4.1 Population and Demography

Area of Local Direct Influence

Village information from the 2014 census was not available at the time of the survey. Therefore the population figures for the villages in the ALDI shown in the "Best estimates" column of Table 6-52 come from a balanced evaluation of data obtained from different sources, including:

- Estimates by village chiefs;
- Last official figures from 1998 census - including relative projections;
- Evaluation of available satellite imagery of the village;
- Estimated number of members per household (e.g. 10); and
- Latest migration trends on specific areas/villages (e.g. ASM operations around Kouakougnanou).

Figures show that the most significant communities in the Study Area, by population, are Allahou Bazi and Angovia – two adjacent villages in close proximity to Project facilities. Kouakougnanou is also another important community in the area because it is growing due to increasing migration of artisanal miners. The temporary camp of Petit Abidjan is situated on lands belonging to Kouakougnanou that are not far from the village itself. Akakro and N'Da Koffi Yobouekro are smaller communities in the Western periphery of the project footprint.

Table 6-52 Population of the priority villages in the Study Area (Source rePlan, March 2015)

Village	Census 1998	Census 2014	Village self estimat.	Satellite imagery (hh)	Best Estimate
Akakro	373	Missing	500	60	550
Allahou Bazi	713	Missing	5 000	420	4 200
Fishermen CF1 (Allahou Bazi)	Didn't exist	Missing	500	30	350
Angovia	809	Missing	5 000	350	3 500
Kouakougnanou	335	Missing	1 000	210	1 800
Petit Abidjan (Kouakougnanou)	Didn't exist	Didn't exist	2 000	Unavailable	2 000
N'da Koffi Yabouekro.	202	Missing	300	30	315
Total					**12 715**

Area of Local Indirect Influence

Villages and settlements within the ALII, listed in Table 6-44 and illustrated in Figure 6-25 are expected to experience impact Levels of 1, 2, or 3 as a result of the Project. Although the results of the 2014 Census have not been published, site visits to communities within the ALII indicate that it is reasonable to assume that the socioeconomic and socio-demographic features in the ALII are very similar to those in the ALDI. Recent population data for communities in this area of influence are not available, however 1998 Census figures are included Table 6-53 below.

Table 6-53 Population of the villages in the ALII (Source rePlan, 2015)

Community	Census 1998
Allai Yaokro	373
Alley	613
Amanifla	Unknown*
Begbessou	251
Bokasso	Unknown*
Bozi	618
Cf2	819
Cf3	418
Kami	615
Kossou	Unknown*
Patizia	Unknown*
Ngatta ble kouamekro	493
Toumboukro	335

* No information is available for the villages of the Kossou region. However, preliminary sub-prefectoral results from the 2014 census report a population of the 28 321 individuals in the sub-prefecture of Kossou (RGPH, 2014).

Area of Regional Influence

Marahoué Region, where the Project is located, is the seventh most populous region of the country, with 862 344 inhabitants (Table 6-54). The population of Marahoué grew from 562 491 (1998 Census) to 862 344 in 2014, recording an average growth rate of

2.7 % per year. Most people of the Marahoué region live in the Bouaflé Department. The Bouaflé Sub-Prefecture is the most populous in the region.

Cities such as Bouaflé and Yamoussoukro, also located in the Area of Regional Influence, are expected to experience some Project-related impacts. These will be monitored in the Stakeholder Engagement Plan. Site visits to smaller village communities in the Area of Regional Influence indicate that it is reasonable to assume that, with the exception of larger centres such as Bouaflé and Yamoussoukro, the socio-demographic and socioeconomic characteristics there are similar to those in the Area of Local Direct Influence.

Table 6-54 Population Marahoue (Source Census 2014)

Department	Sub-prefecture	Men	Women	Total
Bouafle	Begbessou	10 970	8 817	19 787
	Bononi	60 989	51 640	112 629
	Bouaflé	88 787	78 476	167 263
	Douffoukankro	15 024	14 073	29 097
	Pakouabo	10 942	8 035	18 977
	Tibeita	8 624	7 040	15 664
	Zaguieta	25 386	20 880	46 266
	TOTAL	**220 722**	**188 961**	**409 683**
Sinfra	Bazre	18 373	16 408	34 781
	Kononfla	26 970	23 806	50 776
	Kouetifla	11 606	10 575	22 181
	Sinfra	67 493	62 784	130 277
	TOTAL	**124 442**	**113 573**	**238 015**
Zuenoula	Gohitafla	18 802	16 638	35 440
	Iriefla	2 970	3 259	6 229
	Kanzra	14 336	13 646	27 982
	Maminiguii	12 972	12 075	25 047
	Voueboufla	10 826	9 628	20 454
	Zanzra	9 055	9 490	18 545
	Zuenoula	43 475	37 474	80 949
	Total	**112 436**	**102 210**	**214 646**

6.11.4.2 Ethnic and Religious Diversity in the Study Area

Ethnic Diversity in the Local Study Area

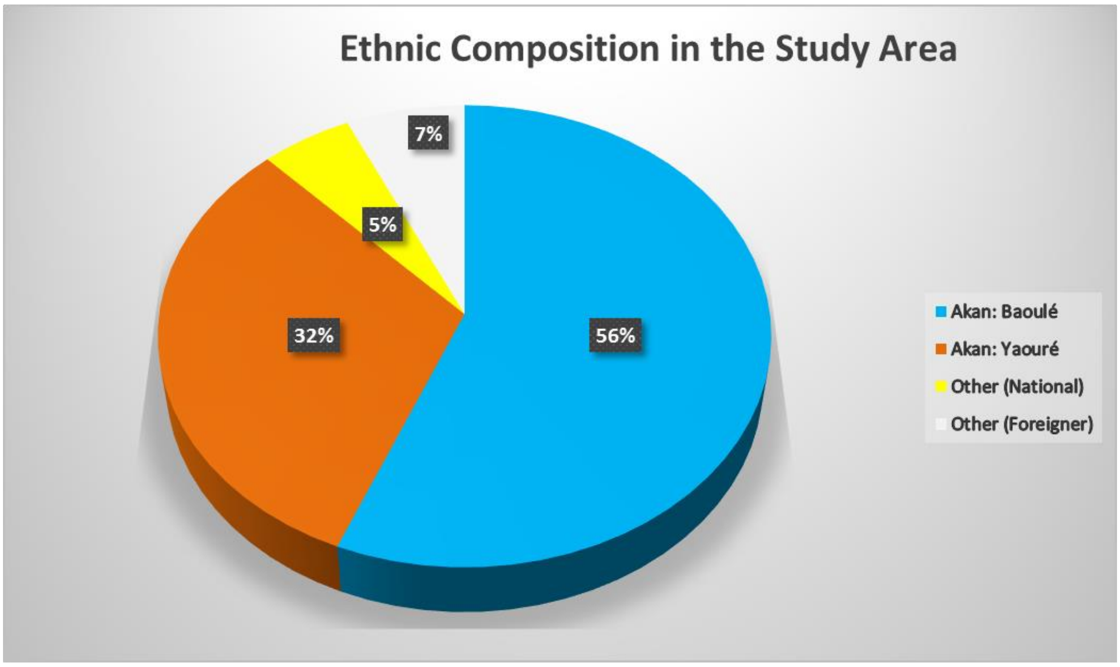
The great majority of individuals in the communities of the Study Area belong to the Akan ethno-cultural family. They represent 42% of the national population and are concentrated in the east-central and southeastern portions of the country. Along with the Mandé, the Voltaic (Gour), and the Krou peoples, the Akan are one of the principle ethnic groups of Côte d'Ivoire, and of these, the largest. The Yaoure sub-group of the Akan ethno-cultural family has been traditionally associated with the Project area. Members of this group were the first inhabitants of Bouaflé. They are represented by two sub-groups, the Yaoure of the South, who are the principal landowners, and the Yaoure of the North, who migrated from the Sakassou region to join the Yaoure of the South.

During the administration of the household surveys, most people identified their families as belonging to the Baoulé ethnic group (Figure 6-30). Both Yaoure and Baoulé belong to the Akan family, however, given the predominance of the Baoulé sub-group at national levels, many Yaoure learned the Baoulé language, intermarried among the Baoule, and tend to identify themselves as Baoulé.

No group that would be defined as indigenous peoples as described in IFC PS7 are present in the Project area.

As a result of artisanal gold mining activities, the Study Area has received waves of migrants from other regions of Côte d'Ivoire and West Africa, resulting in an increasingly diverse ethnic composition within the Study Area. The field surveys identified a significant presence of other national groups, such as Gouro, Yacouba, Sénoufo and Malinke (5%) and of foreigners from Mali, Burkina, Togo, Benin, and Guinea, among others (7%).

Figure 6-30 Ethnic Composition in the Study Area (Source rePlan, 2015)



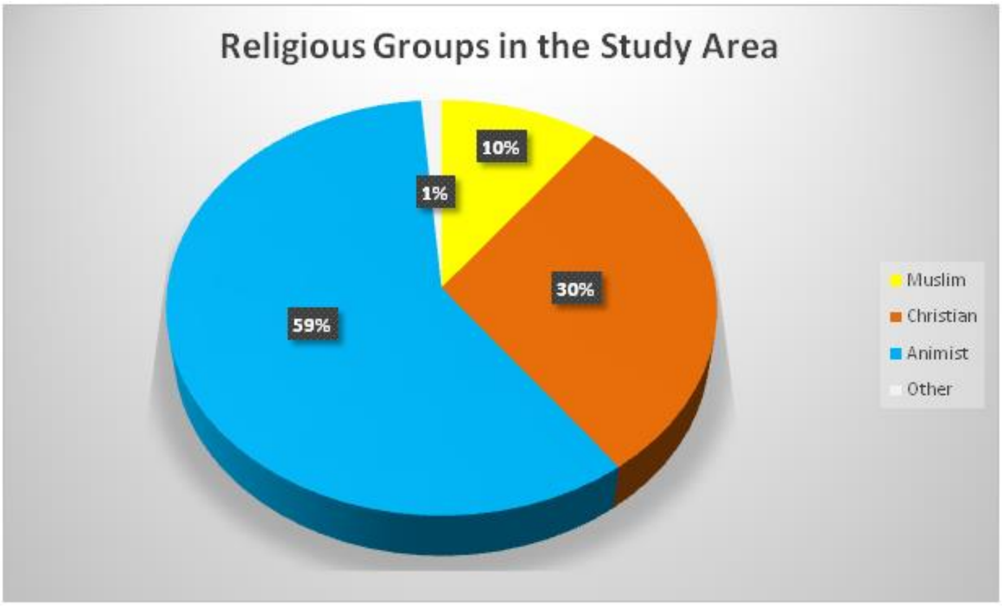
Religious Diversity in the Study Area

Field surveys show that the absolute majority of communities in the Study Area practice traditional, or animist, religions (59%) compared to 11.9% for the country as a whole. However, animists frequently convert to one of two monotheistic religions. The presence of Christian (30%) and Muslim (10%) communities in the Study Area is significant, however there are proportionally far fewer Muslims in the Study Area than in the country as a whole where, at 38.6%, they are the single largest religious group. However, in light of the high proportion of Muslims among the (temporary) local migrant population in the Study Area, at any given time they may be underrepresented in these local figures.

Migration and a significant influx of workers, especially from Burkina Faso, Mali and Guinea Conakry, have influenced the ethnic and religious composition of the Study Area. Most migrants in the Study Area come from predominantly Muslim countries. Field surveys noted a strong presence of temporary Burkinabé settlers employed in the artisanal mining sector. However, given the temporary nature of their presence in the Study Area, these figures are not reflected in the community profiles.

Figure 6-31 below illustrates the composition of the religious groups identified in the household surveys in the Study Area.

Figure 6-31 Religious Groups in the Study Area (Source rePlan, 2015)



Religious Infrastructure in the Study Area

Christian churches can be found in all villages of the Study Area. All Christian confessions in the area (Catholic, Baptist, Evangelical, and Protestant) are represented by one or more religious sites. In the village of Angovia-Allahou Bazi, and in the temporary camp of Petit Abidjan (in the proximity of Kouakougnanou), where the presence of immigrant communities is significant, communities built mosques to serve the religious needs of Muslim immigrants. Many religious structures are built with locally available materials (straw, wood, clay) and are relatively small in size. Table 6-55 below provides an overview of the main religious sites identified during surveys of the Study Area (geo-localisation details and pictures can be found in **Error! Reference source not found.**C).

Table 6-55 Religious Infrastructure in the Study Area (Source rePlan, 2015)

Village	Name	Confession
Akakro	Eglise AECI (picture on the bottom left corner)	Christian, Evangelic
Akakro	Eglise CMA	Christian, Protestant
Allahou bazi	Eglise de dieu	Christian, catholic
Angovia	Eglise CMA	Christian, Protestant
Angovia	Mosquée (picture on the top left corner)	Islamic
Kouakougnanou	Eglise AECI	Christian, Evangelic
Kouakougnanou	Eglise Baptiste	Christian, Baptist
Kouakougnanou	Eglise Assemblée de Dieu	Christian, Protestant
Kouakougnanou	Eglise Catholique (picture on the bottom right corner)	Christian, Catholic
Kouakougnanou	Eglise CMA	Christian, Protestant
N'da koffi yobouekro	Eglise edcj (picture on the top right corner)	Christian, evangelic
Petit abidjan (temporary camp)	Mosquée	Muslim

6.11.4.3 Settlements in the Study Area

In the following Sections, the SEBS provides a historical, political socio-cultural analysis of the villages in the local direct area of influence. More detailed historical, political, and cultural descriptions of each village are provided in **Error! Reference source not found.**D.

Village Profile 1 – Allahou Bazi (including Fishermen's Camps)

Together with Angovia, with which is connected by a continuous stream of dwellings, Allahou Bazi represents the largest community in the ALDI. It is the closest village to the field administrative headquarters of the Company and it is located in the proximity of the main mining site. The population of approximately 4,200 is predominantly Baoulé-speaking of Baoulé origin, though other languages and ethnicities are present in the community. The population is primarily animist, though Christianity, Islam, and Buddhism are also practiced. A Village Chief who enjoys some political and judicial authority governs the village. Youth, women, and foreigners also have representatives among the traditional authorities.

The village originated with the rise of artisanal mining in the area, but its jurisdiction also covers three fishermen's camps with a combined population of approximately 1,500. The village and fishermen's camps have seen periodic conflict between and among villagers, artisanal miners, and fishermen, usually arising from disputes about mining proceeds and fish stocks.

Village Profile 2 – Angovia

Angovia and village of Allahou Bazi have historically served the local community as a basis from which to engage in nearby artisanal gold mining. Considering its size and proximity to Project sites, Angovia has been one of the most important targets of study in the Study Area. Although physically connected to Allahou Bazi, Angovia maintains a separate administrative organisation and a distinct historical and cultural identity. Owing to it's centrality to regional artisanal mining, the village has also known recent violent conflict between villagers and artisanal miners.

Its population is similar in size (est. 3,500) and ethno-religious composition to Allahou Bazi, though it's customary administrative structure differs slightly, with a Chief of Lands charged with administering and arbitrating land issues. The chief is also assisted by other public figures that form part of his staff.

Village Profile 3 – Kouakougnanou

Founded in the late 19th century, Kouakougnanou is the third largest community of the ALDI and is located on the southern periphery of the Project footprint. It has a population of approximately 1,800 (250 households) and is overseen by a Village Chief and a Chief of Lands. The population is predominantly Christian though Muslims, Animists, and Buddhists are also present.

In 2014, following the eviction of some 2,500 artisanal miners from their camps, the village became home to displaced artisanal miners. As of early 2015, the miners' camp, known as "Petit Abidjan", had become the basis for semi-industrial and artisanal mining activity in the area.

Village Profile 4 – Akakro

Akakro is the fourth largest community of the ALDI and it is located at the eastern periphery of the Project footprint. It has a population of approximately 550 (50 households) and is governed by a Village Chief and Chief of Lands. The interests and organisations of youth and women are represented and led by a President of Youth and a President of Women.

Though the population is mainly Baoulé-speaking, the main ethnic group is Yaoure. Predominantly animist, the village is also home to Christians, Muslims, and Buddhists.

Village Profile 5 – N'Da Koffi Yobouékro

N'Da Koffi Yobouekro is the smallest community of the ALDI and it is located at the eastern periphery of the Project footprint, near Akakro. Its population is estimated to be 350 people. The village is linguistically and ethnically Baoulé. Villagers are mostly animist, though there are some Christians. Chief of Sacred Sites, N'GUESSAN

Kouamé Jean, is the principal religious authority. Other traditional authorities are the Village Chief, President of Youth, among other public figures.

Village Profile 6 – Alley

Alley is a predominantly Baoulé and Christian village in the ALII. It has a population of 600 (127 households). A village chief with the support of five additional public figures and a Chief of Lands administers the village.

Since 2014, the village has become home to a group of Chinese semi-industrial miners who established camps along the Bandama River.

Village Profile 7 – Patizia (including Amanifla)

Patizia is a predominantly Yaoure Nampalé-speaking village of 1000 (approximately 300 households) located in the ALII. It is predominantly animist, though it is also home to Christians and Muslims. In 2005 some internal migration was experienced as local residents began to relocate nearer the Bandama River.

The village chief and the chief of lands are both in charge of administering the village. A President of Youth mediates between the village youth and elders and organises local youth in village activities.

Village Profile 8 – Kossou

Kossou is a large village of 7,000 (1,500 households) near the ALDI, founded on the east bank of the Bandama River. A Village Chief, Chief of Lands, and a President of Village Committee, who provides support to the Chief and coordinates the activities of prominent figures in the community, comprise traditional authority in the village. The village is predominantly Baoulé-speaking and Christian, though animism, Islam, and Buddhism are also practiced.

In the 1970s when the Kossou Dam was built, Kossou lost access to significant lands and forests and the villagers claim they were unfairly compensated.

6.11.4.4 Household Characteristics

Head of the household

In traditional rural societies such as those of the Study Area, the head of household is a patriarch with responsibility for and authority over other members of the household. He is normally the oldest member of the "generation of fathers." Often an elderly man, he may be assisted in carrying out his tasks by his sons and younger brothers. In the priority villages, the average age of the head of surveyed households was 50 years. The oldest household head was 93 years old and the youngest, 20 years old.

Women in the household

In 2012, the proportion of women heading households in Côte d'Ivoire was nearly 18%. Generally, female household heads are widows with no male head of household available to take care of them, whether a brother-in-law or adult male child. There were 33 households headed by women in the sampled population (8,6% of the surveyed households).

Although formally prohibited by law (the 1964 Civil Code), polygamy is widely practiced in rural areas. 10,4% of surveyed male heads of household reported having two or more wives, of whom 94% had two wives and 6% had three wives.

Family law of Côte d'Ivoire also prohibits other traditional practices that are widely practiced in rural areas, including:

- Payment and the acceptance of a bride price;
- (Forced) marriage of women under the age of 18; and
- Non-registration of marriages.

In 2012, the National Assembly approved a gender-equality reform that amended and/or repealed some articles of the 1964 Family Code (e.g. Articles 53, 58, 59, 60, 67) and established the legal parity between men and women regarding: the duty to contribute to family livelihoods (art. 58), the responsibility to decide on family management issues including children's education (59), and family residence (art. 60).

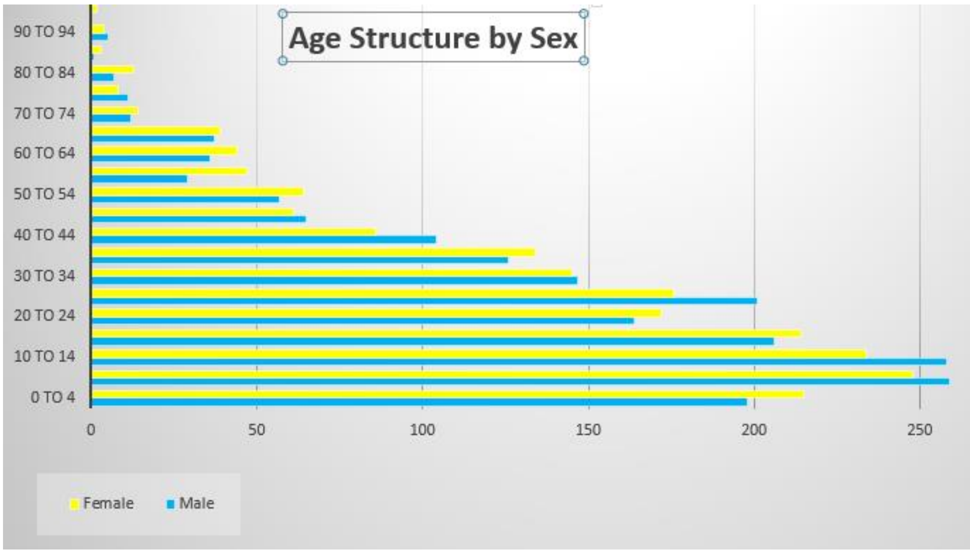
The male/female ratio in Côte d'Ivoire is 1.03:1 (CIA World Factbook, 2013). Household surveys confirm similar ratios in the Study Area, where the ratio is 1.01:1 in favour of men (rePlan 2015).

However, household surveys do not account for the influx of workers to the Study Area engaged in seasonal or temporary economic activities (mainly artisanal mining). These workers are mainly men (estimated at 75% of the migrant population) who migrated without their families given the lack of opportunities for their children to attend local schools or access local sanitation services. During times of high migration flows male/female ratios experience fluctuation. For example, in January 2015, it is estimated that the arrival of more than 2,500 migrants, of whom the great majority were male, increased the male/female ratio of the Study Area to 113 men for every 100 women (rePlan 2015).

Age Structure

The age distribution within rural priority villages is similar to the projected national figures: 40.9% of people aged 0-14 years, 54,8% of people aged 15-64 years and 3.5% of people aged 65 and over (ECOSOC, 2010). These figures reflect high fertility and mortality rates. At the national level, more than 35% of the population is under the age of 15. In rural priority villages, the figures are 36.71% in the 0-14 age group, 59.23% in the 15-64 age group and 4.06% in the 65-99 age group - see Figure 6-32.

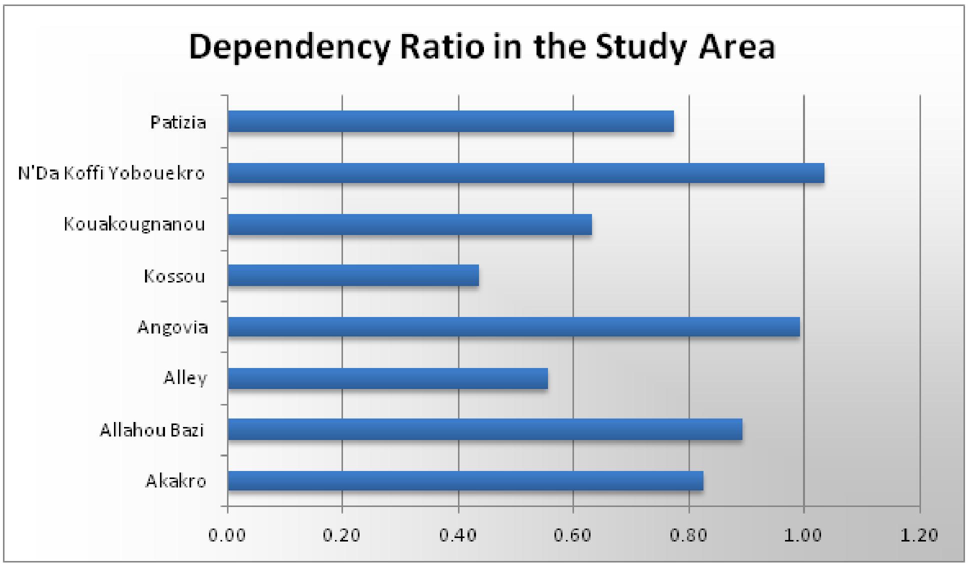
Figure 6-32 Age Structure by Sex (Source rePlan, 2015)



Dependency Ratio

The dependency ratio is calculated by dividing the total number of people younger than 15 and older than 64, by the number of people between the ages of 15 and 64. The average dependency ratio in the Study Area is of 77 inactive people for every 100 people in the workforce (a ratio of 0.77). Figures for the Study Area correspond with national indicators - 0.79, according to the CIA World Fact Book (2013). However, there are significant variations from village to village. The villages of Kossou and Alley indicate a ratio close to the 0.50 threshold while Angovia and N'Da Koffi Yobouekro approach an even ratio, 0.99 and 1.03, respectively (see Figure 6-40.

Figure 6-40 Dependency Ratio in the Study Area (Source rePlan, 2015)



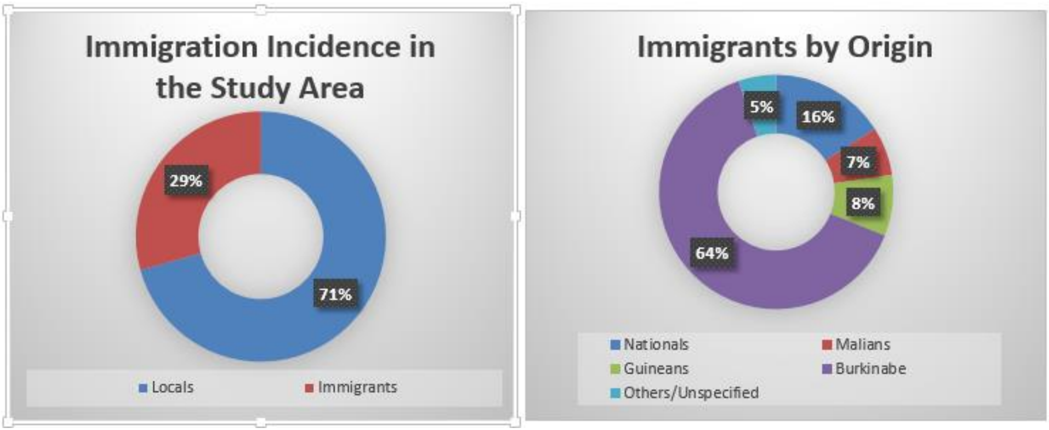
6.11.4.5 Population Movements and Migrations

Recent figures show the net migration rate of Côte d'Ivoire stabilised close to the neutrality threshold of 0, starting in 2005 (CIA World Fact Book, 2012). However, as noted earlier, Côte d'Ivoire is experiencing an increase in immigration following the achievement of post-crisis political stability and corresponding economic growth. Most immigrants originate in the neighbouring countries of Mali, Burkina Faso and Guinea Conakry.

Foreigners in the Study Area

Findings from the field research programme provide insight into migration and temporary and permanent migrant-settlement patterns in the Study Area. As noted in the methodology Section, household surveys only targeted permanent residents (i.e. excluding the population of Petit Abidjan). The figures below show the incidence of immigrants as a percentage of the total resident population and the origin of immigrants (e.g., national or international) in the Study Area. It is estimated that 18% of the population in the Study Area is not from the region, i.e., 700 people (of whom 550 are citizens of Côte d'Ivoire and 150 non-Côte d'Ivoire citizens) out of 10,715 (rePlan, 2015).

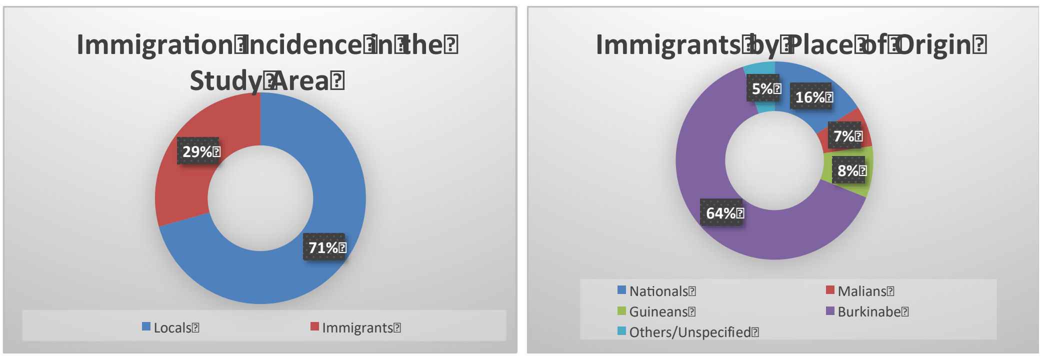
Figure 6-33 Incidence and Origin of Permanent Immigrants in the Study Area (Source rePlan, 2015)



The presence of temporary migrants, most of who are engaged in artisanal mining, has a significant impact on migration figures. The study area experienced irregular migration influxes of artisanal miners based on a number of factors, including: availability of mining land, expected profits, community acceptance and good relations and local authority intervention.

According to site observations and reports from key informant interviews, it is estimated that the biggest camp of artisanal miners (i.e. Petit Abidajn) accommodated roughly 3,500 people when the influx was hitting the tipping point (i.e. January 2015). During the field surveys (March 2015), the chief of the camp reported that Petit Abidjan was experiencing an outflow of miners towards other regions, bringing the overall population down to roughly 2,000 people. Artisanal miners in Petit Abidjan come mainly from Burkina Faso, with some presence of Guineans, Malians and citizens of Côte d'Ivoire from other regions. Figure 6-33 aggregates data on temporary and permanent migrant populations and illustrates incidence of migrant populations in the Study Area and the relative weight of the Burkinabe community among immigrants in the Study Area.

Figure 6-34 Incidence and Origin of Temporary Immigrants in the Study Area (Source rePlan, 2015)



6.11.4.6 Education and Literacy

National Profile

The education system of Côte d'Ivoire is administered by the Ministry of National and Professional Education (Ministère de l'education nationale et de l'enseignement technique) and the Ministry of Higher Education and Scientific Research (Ministère de l'enseignment supérieur et de la recherche scientifique). The education system comprises four stages:

- Kindergarten or pre-primary education is usually available only in urban areas and schools are mostly private;
- Primary school lasts six years, leading to a certificate of primary studies;
- Secondary school lasts seven years, leading to a certificate or baccalauréat; and
- Public university education, available only in Abidjan and Bouaké, culminates in a university degree (licence after 3 years, or master after 5 years). A large number of private technical and teacher-training institutions provide post-primary and post-secondary education.

Most public schools are tuition free, although students are expected to pay an entrance fee and purchase uniforms. Most supplies are free and some students receive government scholarships, usually in return for a period of government employment following graduation.

Table 6-56 reports the main national education and literature indicators compared with average trends in Sub-Saharan countries.

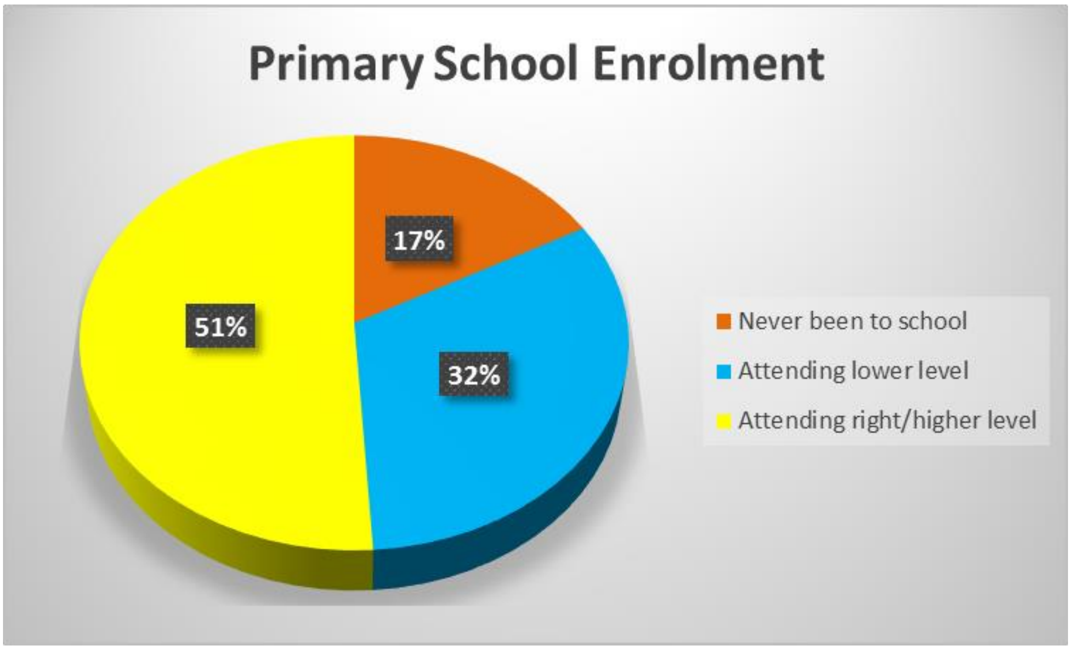
Table 6-56 National indicators on Education and Literacy (Source World Bank, 2015)

Indicator	Côte d'Ivoire	Sub-Saharan Africa
Adult literacy rate (% of people aged 15 or above)	41%	59%
Youth literacy rates (males aged 15-24)	58,3%	75,5%
Youth literacy rates (females aged 15-24)	38,8%	64,1%
Primary school enrolment rate	61,9%	76,8%
Ratio men-women on primary school enrolment	(0.86) 86%	(0.92) 92%
Secondary school enrolment rate	29%	32,5%
Ratio men-women on secondary school enrolment	(0.678) 67,8%	(0.838) 83,8%
Government spending (% of GDP)	4,6%	4,4%

Throughout the Study Area, children are often enrolled in primary school courses. However, social surveys indicate that a significant portion of uneducated parents do not see the necessity of sending their children to public schools. This is especially the case when there is no public school close to the village or if the household requires the active participation of children in family livelihood strategies (e.g., working in the fields).

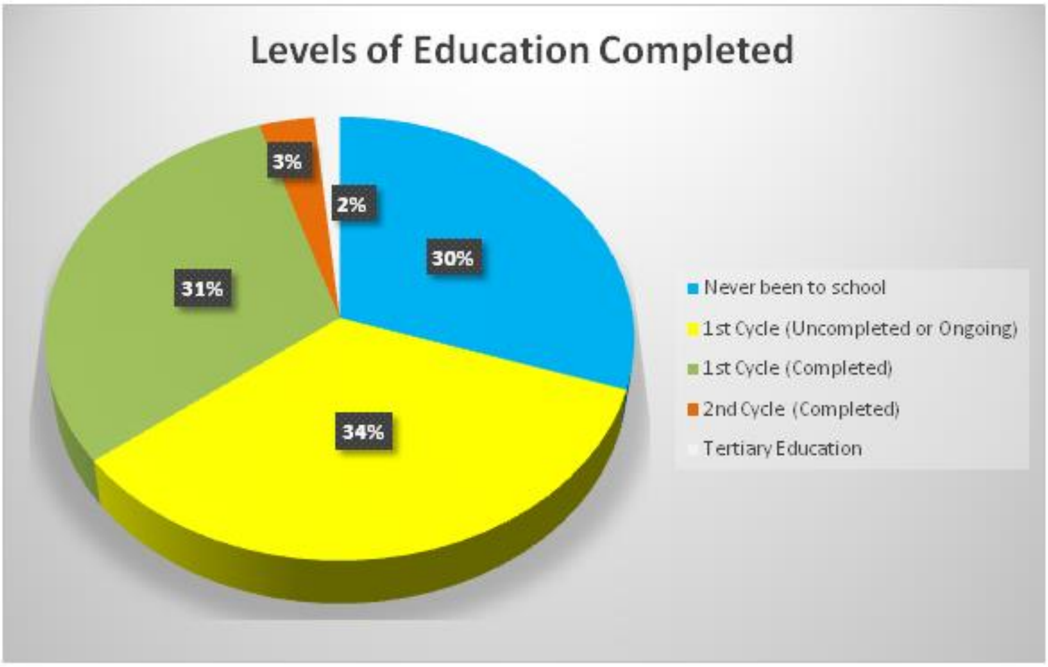
Data collected during the survey indicate that 17% of children of primary school age (5-11 years) have never attended school. 51% of school-age children report to be lagging behind the standard curriculum, as a result of failing the year or due to late or part-time enrolment (Figure 6-35).

Figure 6-35 Primary School Enrolment in the Study Area for Children of School Age (Source rePlan, 2015)



Regarding secondary education, there are significant limitations in terms of access in the Study Area. The closest secondary school to the ALDI is in Kossou. However, children in the ALDI must enrol in schools within their sub-prefectures, and Kossou belongs to a different sub-prefecture than that of the ALDI (Kossou Sub-Prefecture vs. Bouaflé Sub-Prefecture). Therefore, all children who wish to continue their education must relocate to Bouaflé or to other towns in the Bouaflé Sub-Prefecture (rePlan, 2015). Figure 6-36 highlights the effects of lack of access to education at all levels. Only one out of three people in the Study Area has achieved a primary school diploma and only 5% of the population has completed the higher (tertiary) education cycle.

Figure 6-36 Levels of Education Completed in the Study Area (Source rePlan, 2015)



School Infrastructure in the local area

There are 5 primary schools and no secondary schools in the ALDI. All primary schools in the ALDI have been registered and geo-localised (see Appendix D). Table 6-57 provides a list of primary school infrastructure in priority five villages.

Table 6-57 School Infrastructure in the ALDI (Source: Ministry of Education, 2015)

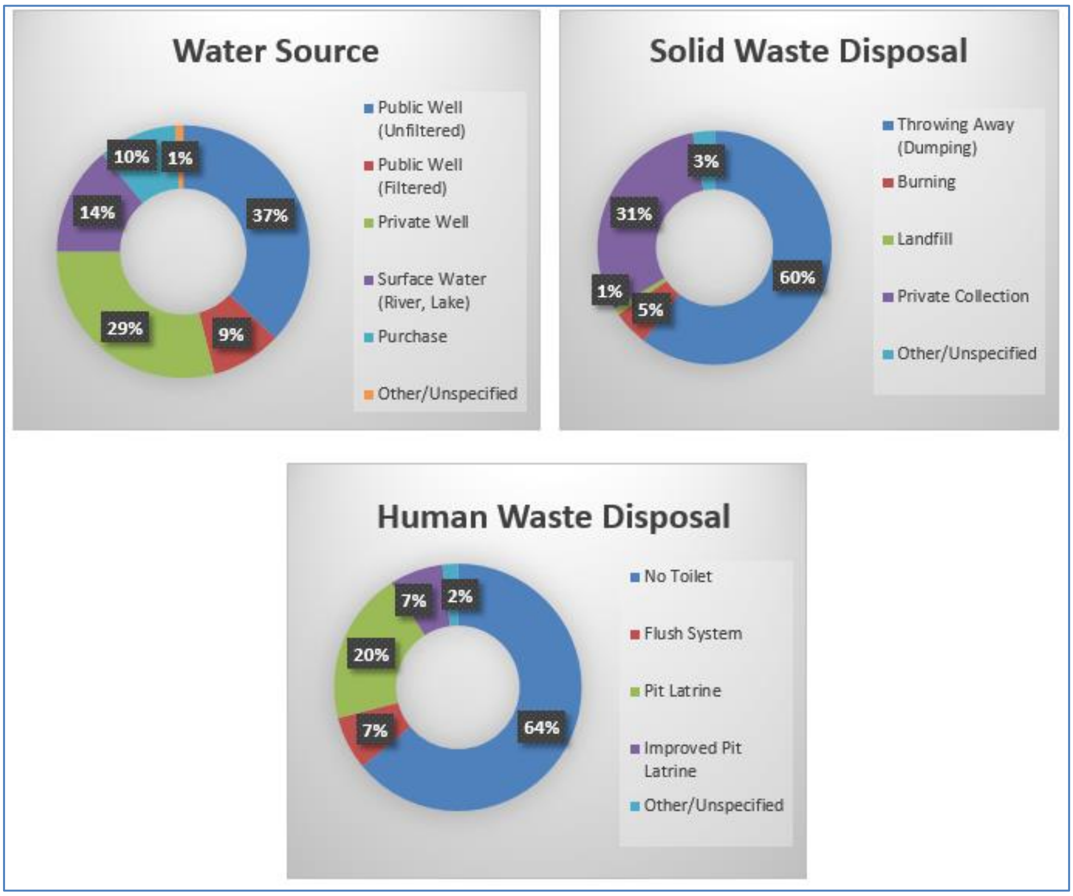
Pedagogic Sector	Village	Name	Students (M)	Students (W)	Teachers
ANGOVIA	AKAKRO	EPP AKAKRO	196	96	6
ANGOVIA	ANGOVIA	EPP ANGOVIA 1	275	136	8
ANGOVIA	ANGOVIA	EPP ANGOVIA 2	347	168	6
BOZI	KOUAKOUGNANOU	EPP KOUAKOUGNANOU	293	135	7
BOZI	YOBOUEKRO	EPP YOBOUEKRO	183	95	5
			1294	630	32

6.11.4.7 Living Conditions

Sanitation and Hygiene

This Section deals with sanitation and hygiene conditions registered in the Study Area during the social surveys. The main indicators analysed in this Section are: access to quality water sources, solid waste disposal, and human waste disposal. Figure 6-37 illustrates the results of the interviews conducted with surveyed households.

Figure 6-37 Hygiene and Sanitation Practices in the Study Area



Water Use

Social surveys indicate the main sources of water for communities in the Study Area are boreholes and traditional wells, both public and private, followed by surface water sources such as rivers, streams or lakes, and purchase of bottled/filtered water (see Figure 6-37). Villages get their drinking water for domestic uses mainly from surface water, for example, directly from rivers, streams, backwaters, and lakes. However, borehole water is the main source of drinking and cooking water for surveyed households in the priority villages.

Access to good quality water is a main challenge in the Study Area and a source of concern for many surveyed households. Some of the reasons are listed as follows:

- In the dry season, when the water levels are low, many surface water sources are polluted, leading to increases in dysentery, diarrhoea, cholera and other water-borne diseases;
- People and livestock use the same water sources. While areas for water collection for people tend to be distant from areas frequented by animals, the potential for downstream contamination is high;

- The use of chemicals in the artisanal mining process threatens the quality of both surface and underground water reservoirs; and
- An acknowledgement by the local population that they would need better quality water to improve their health and sanitation conditions.

Error! Reference source not found.E identifies the main improved sources and access points for potable water in the ALDI.

Solid Waste Disposal

With regard to solid waste management, the results of the social surveys and field observations indicate that waste management is a significant problem in the region. There is very little evidence of advanced systems of collecting, re-using, re-cycling, and disposing of solid waste. Over 60% of surveyed households reported that they dump their domestic waste on the natural environment (see Figure 6-37). The situation is worse in temporary camps where lack of planning for, and management of solid waste leads to the accumulation of dirt and dumps in some areas.

Sanitation and Human Waste Disposal

Rural areas of the region have a low coverage rate in terms of latrines: 64% of the population does not use any latrine. The proportion of people using latrines adds up to 34% with 20% using covered latrine and 14% improved latrines or flush toilet (see Figure 6-37).

Housing

This section deals with housing conditions observed in the Study Area. The main indicators analysed under this Section are: the quality of materials used to build roofs, floors, and walls of residential structures, and access to electricity and fuels. The following paragraphs provide detailed results of the interviews with the surveyed households. One of the key findings shows that a typical residential structure in the Study Area consists of a house structure with homestead land around it. This information is important to understand some of the data to be presented below.

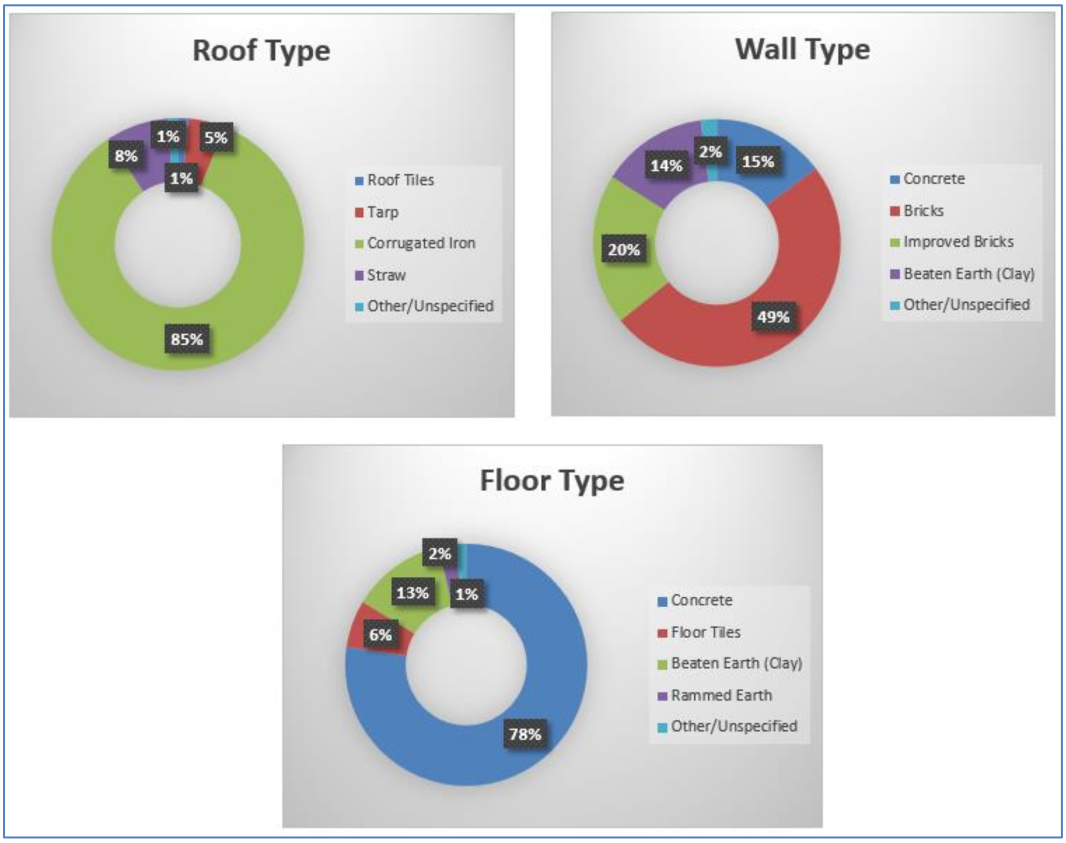
Building Materials

Figure 6-38 shows that corrugated iron is the prevalent coverage material for house roofs (85%). However, less stable options such as straw (8%) and tarp (5%) are commonly used for roofing.

According to Figure 6-38 walls are built with a larger variety of construction materials. Brick is most common (69%), with two options available in local markets. One is more expensive and resistant ("improved brick"). Concrete and beaten earth, represent the most common alternatives to brick (15% and 14% of households, respectively).

Surveys indicate the large majority of households opt for concrete as a construction material for floors (78%), with beaten earth (13%) and floor tiles (6%) as common alternatives (see Figure 6-38).

Figure 6-38 Building Materials for Residential Structures in the Study Area

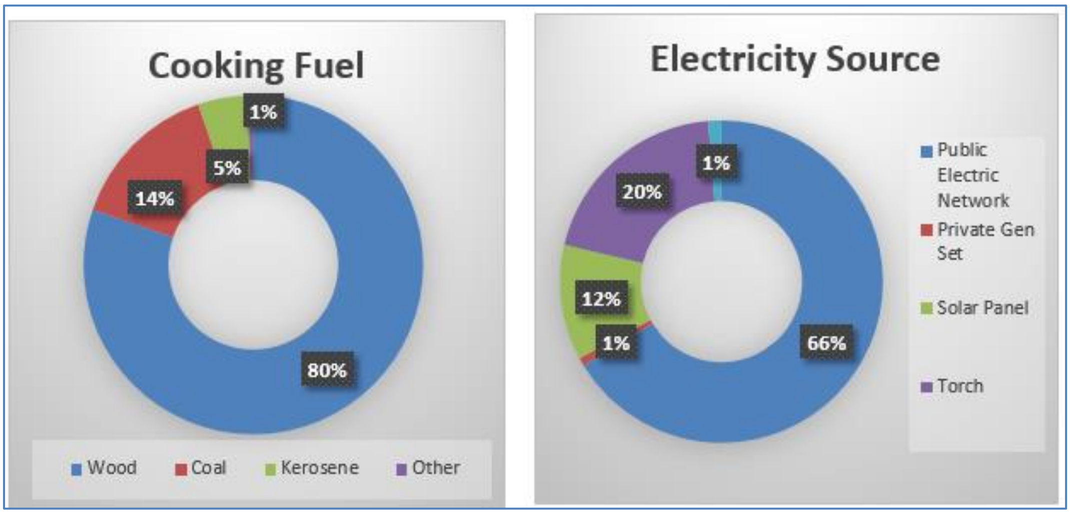


Electricity and Fuels

Access to energy sources allow local communities to access basic services / utilities and improve their quality of life. These services include electricity to provide lighting to the villages and fuels for cooking and/or heating. Figure 6-39 illustrates that two thirds of the Study Area is connected to the transmission lines of the public electricity network. However, the majority of smaller/peripheral hamlets, temporary camps and newer villages have no access to the public network and must generate electricity and energy in other ways, such as private generators for the wealthiest households, solar panels or, in the worst cases, flashlights with batteries.

There is no evidence of households having access to gas networks for either cooking or heating in the Study Area. For most households, the main cooking fuel is wood that can be harvested in great quantities in the area (80%). Coal and kerosene are also used, but with less frequency (14% and 5%, respectively) (see Figure 6-39).

Figure 6-39 Electricity and Fuels in the Study Area



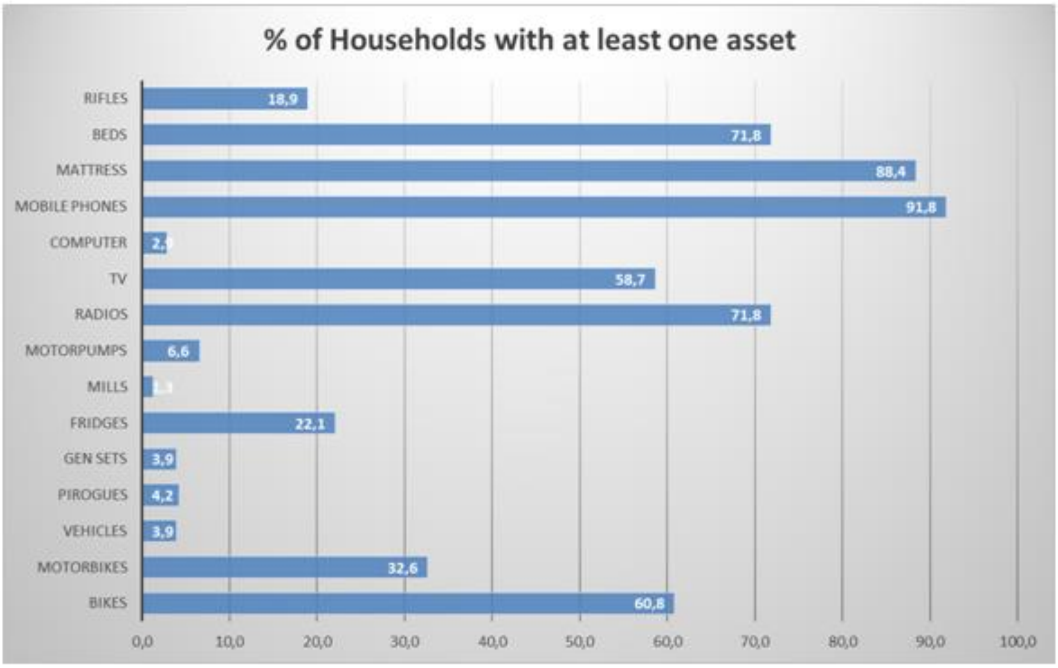
Additional material assets

The social surveys take into consideration other valuable assets that can improve the quality of life of the surveyed households, including, transportation, communication, and furniture, for example. Interviewees were asked to indicate whether their households possess one of the items in a list of key indicators that included: bicycles, motorcycles, other vehicles, and pirogues for transportation; radios, TV, computers and mobile phones for IT & communication purposes; beds and mattresses for furniture; and rifles, mills, and motor pumps, and other assets that might be used to support community livelihood strategies.

In terms of telecommunication, people are mainly dependant on mobile networks for telephone services, with varying reception. National television and radio reception are, however, good. Figure 6-40 indicates that mobile phones (91,8% of the households), radios (71,8%) and TVs (58,7%) are frequently used.

In terms of transport, a significant majority of households use bicycles as their primary mode of transportation. Motorcycles are also frequent (32,6% of the households), in contrast to 4-wheeled motor vehicles (3,9% of the households).

Figure 6-40 Percentage of Households with Access to Valuable Assets



6.11.4.8 Income and Expenditure

Most interviewees found it difficult to quantify their monetary revenues, especially those revenues based on agricultural activity. Almost 50% of households could not provide an estimate of their monthly revenues. This is a result of the irregular nature of agricultural revenue, which fluctuates according to season, changing household consumption needs, as well as other considerations.

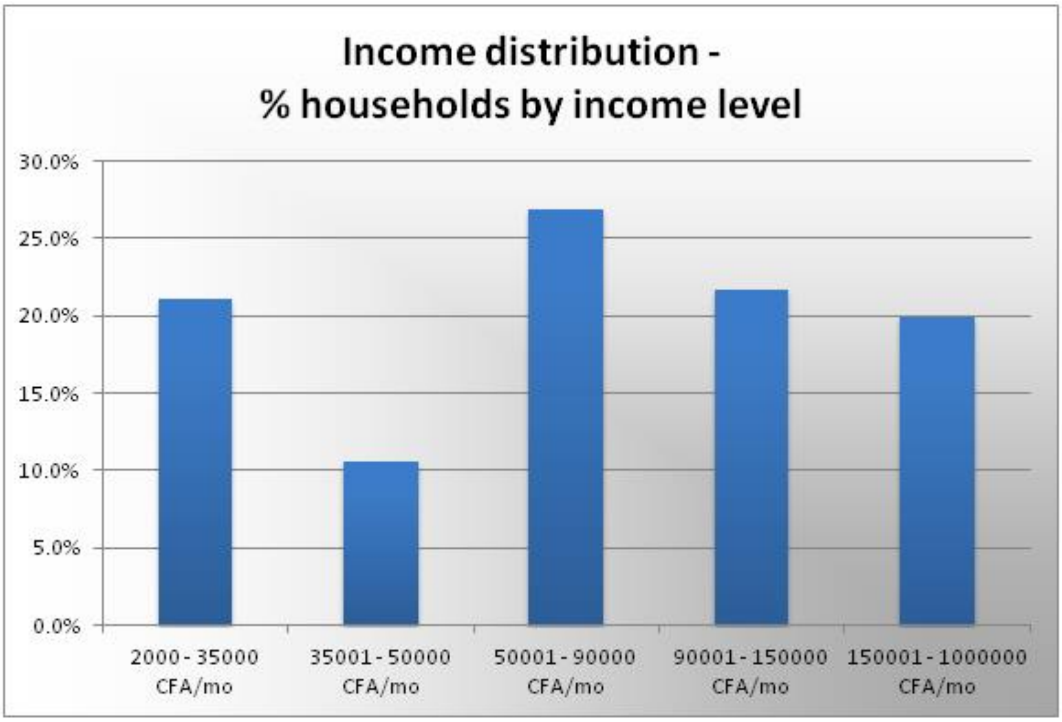
Bearing in mind the restrained sample of respondents, this SEBS estimates that that an average household in the Study Area manages the equivalent of FCFA 120,000 per month (the equivalent of USD 198 – OANDA, April 2015), or FCFA 1,400,000 per year (the equivalent of USD 2,376). In terms of expenditures, it is calculated that an average household spends FCFA 85,000 per month (the equivalent of USD 140), or FCFA 1,020,000 per year (the equivalent of USD 1,682). The average net of monthly revenues and expenditures among households that estimated both income and expenditure is +38,000 FCFA (Table 6-58).

Table 6-58 Average Monthly and Annual Savings in the Study Area (Source rePlan, 2015)

Revenues		**Expenditures**		**Net**	
FCFA	USD	FCFA	USD	FCFA	USD
120,000 / m	198	85,000	140	35,000	57
1,440,000 / y	2,376	1,020,000	1,680	420,000	684

Data collected from household surveys shows that 50% of households that could estimate their monthly income made less than the median of 85,000 FCFA per month. The poorest 20% of households made, on average, just over 20,000 FCFA. These same households account for only 3% of total income reported by the households surveyed. By contrast households in the highest quintile account for 55% of all income generated by the surveyed households (see Figure 6-41).

Figure 6-41 Percentage of Total Income of Surveyed Households by Income Level (Source rePlan, 2015)

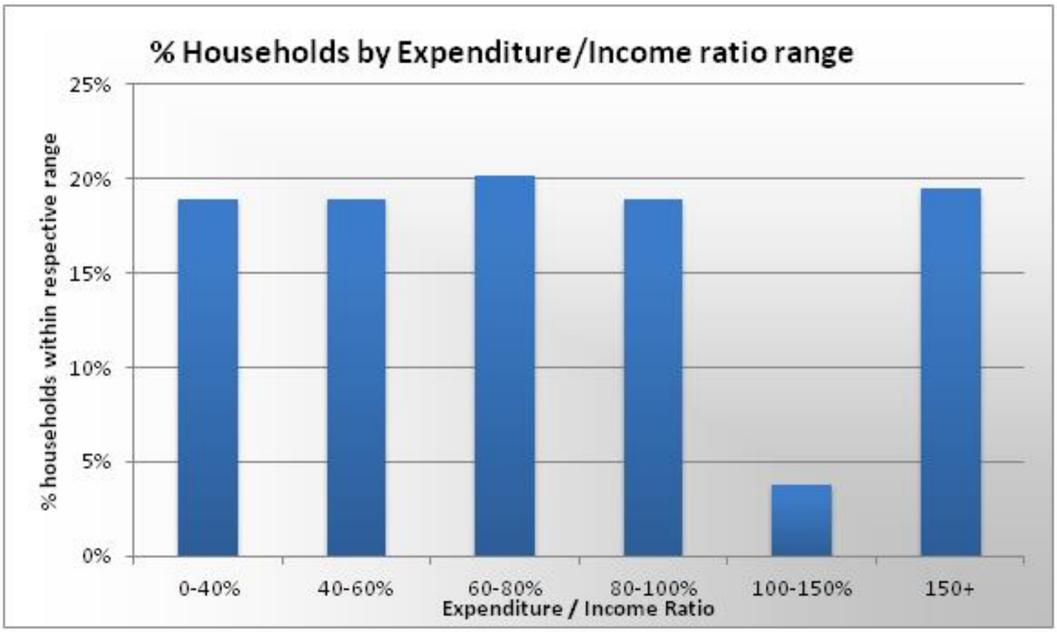


Social surveys indicate that, on average, there are 10 individuals living within each household in the Study Area. With monthly revenues of 198 dollars per month per household, each individual makes, on average, less than USD 1 per day (USD 0.66 per day per individual). However, these monetary revenues do not include yields from agricultural activities, animal husbandry, non-monetary exchanges of goods, and eco-system services, which partially explains how, despite living at or below the poverty line[5], a significant number of households report a positive net income.

Although aggregate figures show a net positive balance sheet for the communities of the Study Area, some households report a negative balance sheet. 23% of households reported expenses that exceed revenues. 4% reported balance sheets that are null. The situation at the bottom of the income scale is more severe. Amongst the poorest 20% of households (by income), more than 50% reported monthly income shortfalls. Figure 6-50 below illustrates that there is a significant portion of the population (19%) that has expenses that are more than 1.5 times higher than their revenues.

[5] Intended as the minimum level of income deemed adequate in a particular country. The most common poverty indicator is the threshold of 1 USD a day per person (1.25 after the World Bank re-evaluation of the Purchasing Power Parity in 2008)

Figure 6-50 Distribution of Expenditure/Income ratio in the Area of Study (Source rePlan, 2015)



6.11.5 Livelihoods

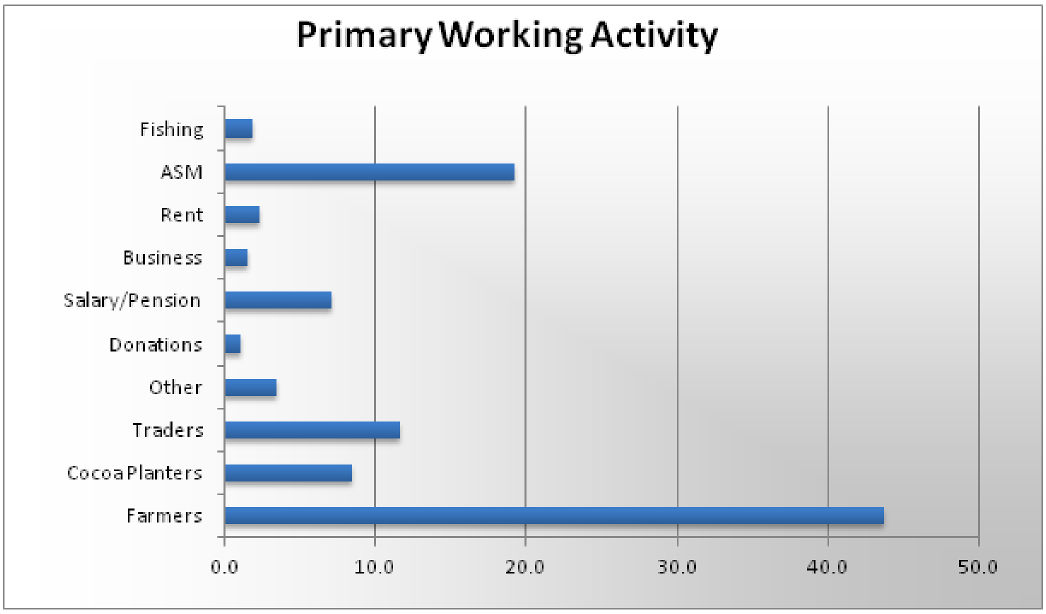
6.11.5.1 Overview

In the Study Area, households and communities have adopted various livelihood strategies to ensure their basic needs are met, and, in cases where surpluses can be generated, to improve their overall standard of living. To ensure subsistence, households combine available resources (land, labour and capital), technology (tools, agricultural equipment, irrigation, etc.) and social networks (mutual aid associations, cooperatives) with knowledge and experience. In this Section, the SEBS describes the socio-economic conditions of the surveyed households with regard to livelihood strategies, capital goods, and vulnerability.

Work Activities

Most households in the Study Area rely on a multiple-source livelihood system. During the social surveys, 74% of households reported that their revenues derive from at least two or more economic activities. The majority of people surveyed are employed in two main economic sectors: agriculture, including cocoa, coffee, and fruit trees, and artisanal mining. Figure 6-42 illustrates that agriculture remains the primary sector of work (43.7% farmers and 8.4% of cocoa planters), followed by artisanal mining and petty trade.

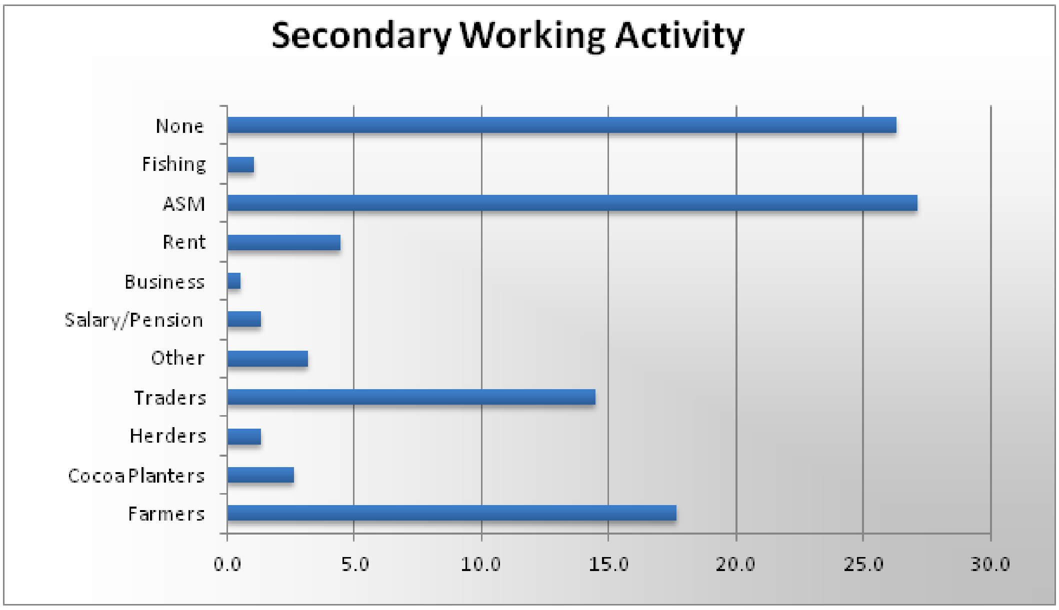
Figure 6-42 Primary Work Activities in the Study Area (Source rePlan, 2015)



Analysis of secondary work activities shows that agricultural revenues alone do not meet community revenue needs. Artisanal mining (both digging and washing) is the most often cited source of secondary work activity (27,1%). Other ancillary activities include commerce, including sale of agricultural products (14,5%), renting rooms, apartments and land (4,5%), herding (1,3%) and fishing (1,1%) – See Figure 6-43.

Some community members within the Study Area also generate income from other sources, such as rents, profit sharing, or salaries and wages. 7,1% of interviewees report to be receiving a monthly salary or pension from their employer or former employer (often these are civil servants, teachers or public workers). 1,6% of households derive profits from running small or medium-sized businesses. Odd jobs (accounted for as "Other" in Figure 6-43 below) and rental activities provide additional revenues to the households of the Study Area.

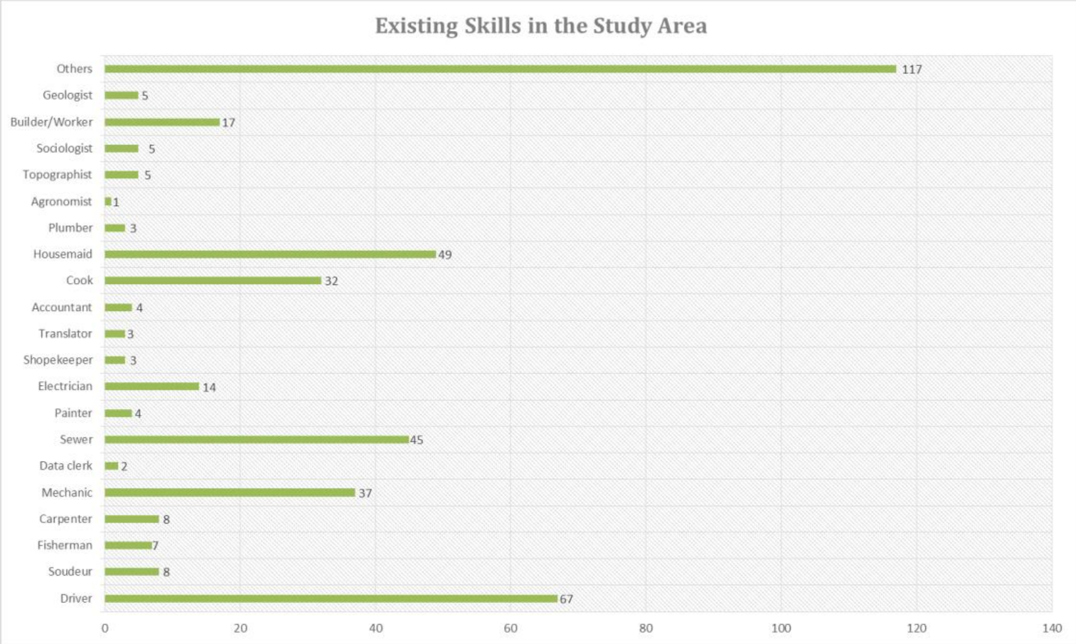
Figure 6-43 Secondary Work Activities in the Study Area (Source rePlan, 2015)



Professional Skills

Previous mining operations in the area have resulted in the existence of certain specific skills in the communities surrounding the Project. Some of the most common skills encountered include drivers, mechanics, plumbers, cooks, carpenters, electricians, housemaids, etc. More specialised and technical skills were also observed in the information collected through the household surveys. Professionals in accounting, topography, agronomy, sociology and geology were among the members of households surveyed (see Figure 6-44).

Figure 6-44 Existing Professional Skills in the Study Area (Source rePlan, 2015)



Capital Goods

Owing in part to a scarcity of formal financial institutions in the Study Area, most households report that formal banking or financial institutions do not manage their savings or debts. Only 19% of households declare savings in a bank account and only 3% have borrowed from a bank (see Figure 6-45). Cooperatives also facilitate access to credit for households, and many execute banking and financial transactions through the Orange money account. Orange, one of the main providers of mobile phone services at the national scale, also offers a variety of banking services, including money deposit and withdrawal, bill payment, and money transfer, in addition to mobile balance recharge.

Households in the Study Area complain that financial and economic conditions are worsening compared to the previous 12 months. Figure 6-46 illustrates that almost two thirds of households report their conditions to be slightly or significantly worse over the past year, while only 25% of the sample reported an improvement (19% reported slight improvements and 6% reported significant improvements). This level of satisfaction affects the choices of more and more community members to abandon traditional livelihoods based on agriculture in order to engage in cash-generating activities such as mining.

Figure 6-45 Capital Goods in the Study Area (Source rePlan, 2015)

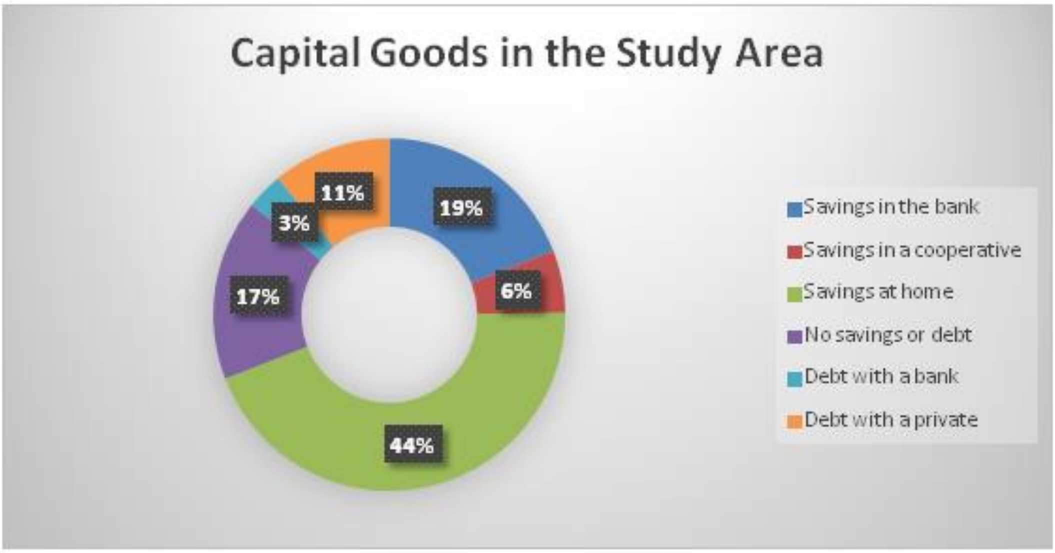
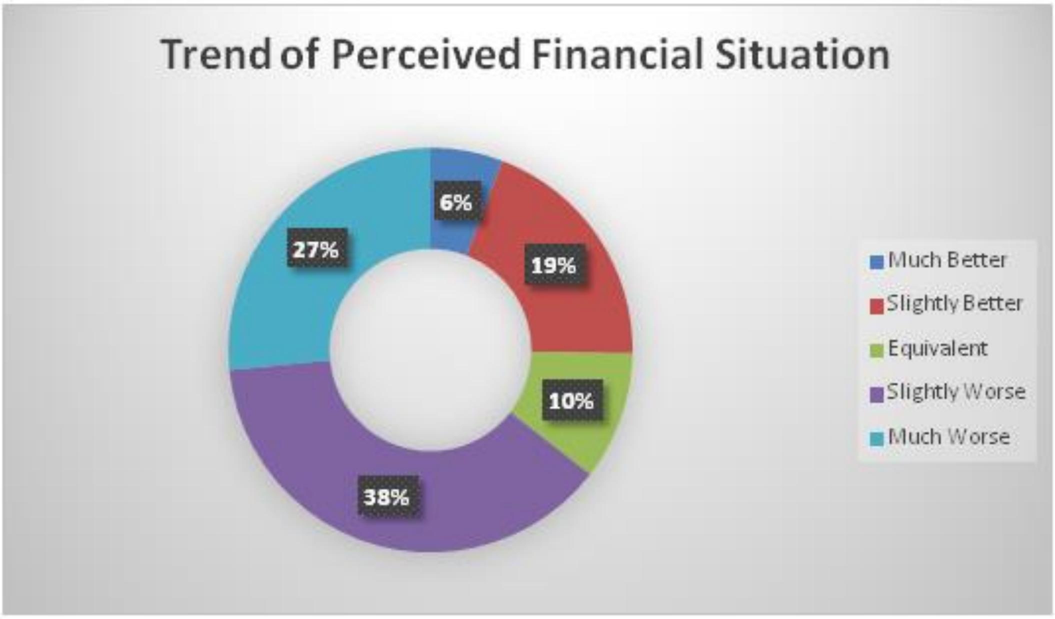


Figure 6-46 Trend of Perceived Financial Situation (Source rePlan, 2015)



6.11.5.2 Agriculture

History of Agriculture

Since its independence, Côte d'Ivoire's economy has been based on the export of agricultural products, the most important of which are coffee and cocoa. This has led to an extraordinary development of these two (2) crops, turning Côte d'Ivoire into the world's largest producer of cocoa. Though cocoa has been introduced in the region of Bouaflé. This region is also known as the "Cocoa Belt" because is where the country's most important cocoa production areas are concentrated. As a result of climate change and soil depletion, the Cocoa Belt moved west, spurring internal and external migration.

People in the Yaourè Project Area primarily settled there to practice artisanal gold mining. However, due to the presence of a lush forest and pressure from colonial authorities, these populations also engaged in traditional agricultural activities, growing cash and food crops.

Farmers and Farm Workers

An analysis of available data shows that agriculture is practiced by at least 94% of households in the Study Area. The majority of household members are indigenous to the area. On average, each household has three (2.9) agricultural plots. The average size of an agricultural plot is about 1.5 hectares. However, it should be noted that agricultural products are not processed in the Project area.

The agricultural workforce consists of mature household members and sometimes paid labourers who earn an annual income of between FCFA 120,000 and 200,000. Agricultural workers are becoming increasingly scarce and expensive because able-bodied workers prefer gold panning for its cash flow potential. Upon completion of the harvest, the family members of farmers receive a certain amount of money from the head of the household.

The average age of farmers in the Study Area is increasing because their prospective heirs often prefer gold panning activities that generate daily incomes. This situation could be worsened by the expected employment opportunities from the Project. This highlights the vulnerable state of agriculture in the region.

Organisation of Farmers

Agence nationale d'appui au développement rural (ANADER) agents provide Agricultural services to farmers in the Study Area. These free services are limited to semi-monthly advice provided to farmers.

Farmers, except those in Kossou and Patizia, do not belong to any cooperative or agricultural organisation. Those farmers who do belong to cooperatives have access to loans at the beginning of the school year, can sell their produce at prices set at a national level, and receive financial support if needed as well as dividends at the end of the crop year.

Crop Cycles

The crop cycle begins with land clearing between January and March. Rice and yams are planted between March and April, at the beginning of the rainy season. Women plant vegetables (tomato, okra, pepper, and eggplant) and weeding is completed from May. The time of rice harvest depends on the seed variety (2, 3, or 4 months) and starts in June. Yams are harvested from December. Since food crops are most often grown alongside cash crops, men plant additional crops, such as plantain, to provide shade for the cocoa seedlings. The weeding of plantations already in production starts in June.

Inputs Used by Farmers

In Côte d'Ivoire, and Angovia in particular, agriculture is generally undertaken using small and simple agricultural implements like machetes and hoes. Occasionally more modern tools are used in plantations as well as pesticides and insecticides, but in general agriculture is not mechanised. These inputs are purchased in Bouaflé, Toumokro, Yamousoukro, from the ANADER agents, or from cooperatives operating in certain villages.

Land Access Modes

Farmers believe that lands allocated for agricultural purposes are insufficient, due primarily to rugged terrain and population growth. Thus, the fallow technique used by farmers to rejuvenate the soil has been reduced from 8 years to between 2 and 5 years. Unfortunately change has had the effect of worsening agricultural output.

Our field surveys show that farmers also practice crop rotation. Thus, once rice or yams are harvested, farmers plant corn or peanuts.

Non-natives who wish to practice agriculture in the Project's area of influence can access land in three different ways: buying, renting or sharecropping.

Income from Agriculture

Agriculture is by far the dominant economic activity within the Study Area. Agricultural production is a gender-based activity. Men are more likely to produce and sell cash crops such as cocoa while women tend to produce and sell food crops. Food crops are usually transported from the farms to customers while cash crops like cocoa are generally left to dry and then transported in trucks to the intermediaries that commercialise them.

Food Self-Sufficiency

According to the farmers interviewed, there are two annual periods of food scarcity. The first period is from May to June, just after rice is planted, because farmers use their rice reserves as seed. The second period of food shortage occurs between July and September and affects people whose staple food is yam. This period of scarcity also begins after planting. These shortages indicate that the amount of food produced in the Study Area is insufficient to meet the year round needs of the local population. However, no estimates of food production have been made because producers do not keep statistical data on food crops grown for household consumption.

Food Crops Produced in the Project Area

Food crops produced in the Department of Bouaflé are yam, cassava, plantain, rain-fed rice, lowland rice, corn, peanut, eggplant, okra, pepper, tomato, and cabbage. Table 6-59 below presents the 2014 production figures for these crops.

Table 6-59 Production of Food Crops in the Department of Buoaflé (Source 2D Consulting, MINAGRI 2014)

Crop	Number of Farmers	Land Size (ha)	Production (t) in 2014
Yam	474	315	4,410
Cassava	509	363	4,356
Plantain	423	306	4,896
Rice (plain)	3,487	5,004	9,000
Rice (low lands)	683	654	1,635
Corn	1,304	1,624	2,923
Peanut	251	178	302
Eggplant	49	38.5	500
Okra	147	113	790
Chili	29	19.5	156
Tomato	26	9.9	138
Cabbage	28	13.5	162

The following food crops are grown in association with cocoa:

- Tubers: yams, cassava, cocoyam;
- Grains: rice, and corn; and
- Fruits and vegetables: tomato, okra, pepper, eggplant, peanuts and plantain.

All of these food crops are consumed directly by the households that produce them or are sold at the local market. The main crops grown by the communities of the Study Area are rice and yam, which are their staple foods. There is no statistical data on food crop production in the Study Area. Figure 6-47 shows some of the products being cultivated in the Study Area.

Figure 6-476 Food crops (yam, cassava, gombo, rice) on the Market in Angovia (Source rePlan, 2015)

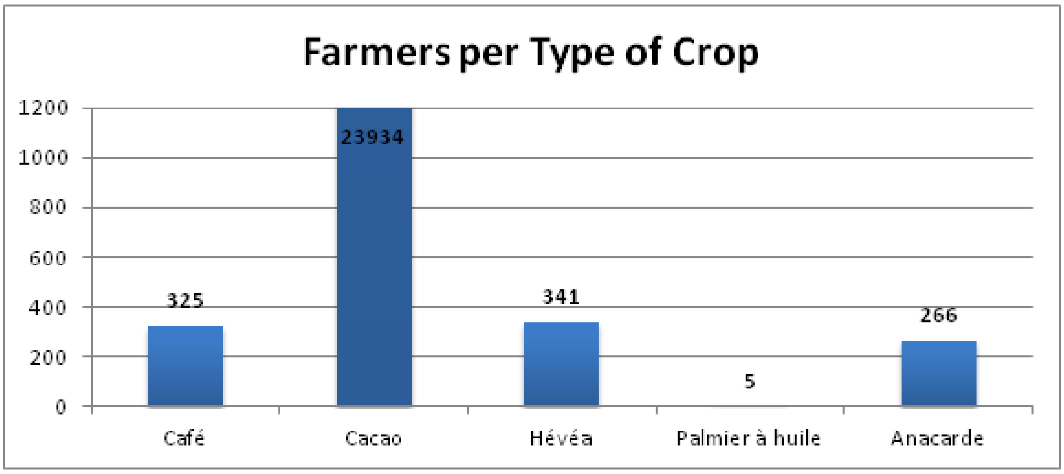
Cash Crops Produced in the Project Area

Cash crops grown in the Bouaflé department include coffee, cocoa, rubber, oil palm trees and cashew trees. Statistical data on the production of these crops for 2014 are listed in the table below.

Table 6-60 Crop Based Producer Distribution (Source 2D Consulting, 2014)

Crop	Number of Farmers	Land Size (ha)	Production in 2014 (t)
Coffee	325	283	141
Cocoa	23,934	79,157	47,494
Rubber	341	1,085	Unavailable
Oil palm tree	5	12	Unavailable
Cashew tree	266	628	Unavailable

Figure 6-48 Crop Based Producer Distribution (Source 2D Consulting, 2015)



As a result of a recent drop in coffee prices, farmers have either abandoned coffee plantations that were subsequently devastated by bushfires or replaced them by cocoa. Coffee is now generally disappearing from the Study Area. In 2014 coffee production was estimated at 3,970 tonnes, whereas overall cocoa production was estimated at 264,031 tonnes (575 producers). Cashew and palm oil trees are newly introduced crops. Cocoa production statistics gathered by the field surveys conducted during the 2014 - 2015 crop year are below in Table 6-61.

Table 6-61 Summary of Cocoa Production in the Project Area during the 2014 – 2015 Crop Campaign (Source 2D Consulting, 2015)

Buyers	Buyer 1	Buyer 2	Buyer 3	Buyer 4	Buyer 5	Buyer 6	Buyer 7	Total
Number of farmers	300	50	60	30	25	60	50	575
Production (t)	69	30	13	10	32.5	70,889	38,642	264,031

The Cocoa Crop Cycle

As a result of incomplete record keeping on part of the interview and focus group informants, local cocoa production figures and statistics are difficult to obtain. However, focus groups allowed for a reconstruction of the cocoa crop cycle, which includes nursery raising, planting, companion planting, and harvesting, is simplified below in Table 6-62. **Error! Reference source not found.**F offers a more detailed description of the cocoa crop cycle.

Table 6-62 Cocoa Crop Cycle (Source 2D Consulting, 2015)

Activity	Season (month)	Inputs
Nursery Raising: Shade Housing, Classifying Bags, and Seeding	October – December	Water source Humus-rich soil Plastic bags / beds Shade houses
Terrain Selection and Planting	Rainy Season, between 6am and 10am (to avoid hottest hours of the day)	Experience, which allows the farmer to assess soil quality and depth Often, yams are planted alongside cocoa to avoid unnecessary land clearing and cleaning, and to enrich soil Often bananas planted between cocoa rows to provide shade for cocoa seedlings and capture atmospheric nitrogen to enrich soil
Clearing	Gradually, over a period of several years	Machetes and chainsaws to clear trees Fire to kill large trees
Cleaning / Weeding / Fertilising	June onwards, at least semi-annually	Machetes, hoes, and axes Pesticides and fungicides
Growing	2 to 5 years	Plant alongside bananas, legumes, which provide shade to seedlings and capture atmospheric nitrogen to enrich the soil
Harvest	3 – 5 years after planting Small season, August – September Peak season, October – January Mid-crop season, February - April	Collect and heap grain (immediately after harvest) Break pods immediately after heaping Fermented for 6 – 7 days Dried for five days Bagged and transported by truck

Agriculture Criticality

Agriculture Criticality is the set of factors limiting agricultural production in the Study Area. The first limiting factor is climate change. Another is pest infestation. A lack of arable land and interference from gold panning, which is becoming an important economic activity in the area, are also factors. In general, gold panning has a negative affect on food security. Initially present in areas such as Begbessou and Bozi, gold panning has spread to many other areas in the department, especially in the Yaourè region. Young people increasingly choose to abandon their family farms to converge on areas of mining activity. As a consequence, agricultural workers are becoming scarce and expensive.

In addition, the remoteness of many agricultural production areas makes it difficult to transport agricultural products to local stores and markets, resulting in a disorganised marketing network, inadequate rolling stock due to degraded agricultural tracks and roads, and high transportation costs. To overcome these limiting factors, farmers must be supported in water management and control using irrigation techniques, by providing them with inputs in order to improve soil quality and plant protective crops to prevent insects. Rural roads must also be reshaped and serviced in order to open up agricultural production areas. To this end the government's policy to end illegal gold panning across Côte d'Ivoire's national territory must be encouraged.

Project-Related Concerns

A sustainable development project must integrate the principles of social equity, environmental integrity and improved economic efficiency. On this basis, citizens' participation in the planning and decision-making process is required in the implementation of development projects. It is in this context that stakeholders express their concerns over the implementation of a project so that they can be taken on board. The stakeholders of the Yaourè gold Study Area have various concerns:

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- The likely departure of the Chinese gold panners from the Bandama coast without completing all the development projects they have initiated for the Alley village population;
- Expropriation of farmlands, which could cause famine in the Study Area area and lower agricultural production at the same time;
- Reshape access roads to various villages and camps to allow for the transportation of agricultural produce and prevent rot;
- Inform the public on the boundaries of the mining area and make sure everyone everyone understands the Project;
- Water and soil pollution due to the use of certain chemicals in the processing process;
- Compensation for lost land and crops to maintain livelihoods;
- Control of migration flows in anticipation of an influx of wageworkers when the Project opens;
- Role of tapes and boundary lines in plantations;
- Priority recruitment of young people in surrounding villages during the operation phase;
- What are the steps taken by Perseus Mining with respect to the presence of cemeteries and sacred forests on the Study Area site?;

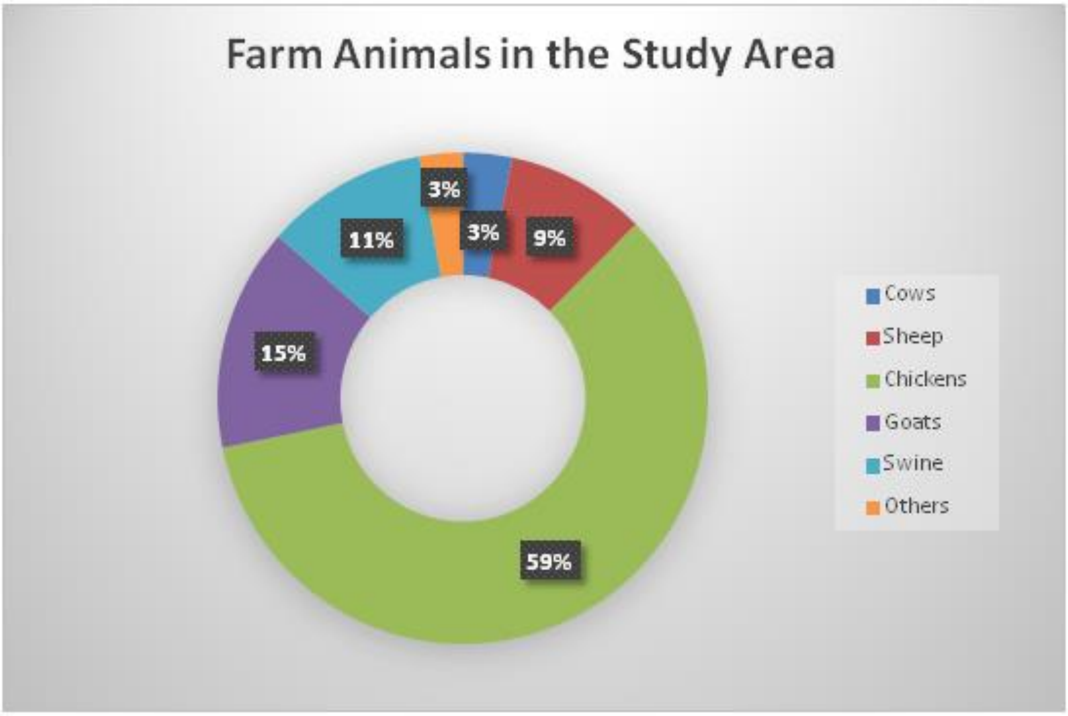
- The company uses chemicals that seep into the ground; waste is discharged next to water points. What steps does the Company consider taking to prevent water contamination;
- How far from a village can a mine site be opened?; and
- Additional housing must be built in Angovia so local people can use it after mining operations are completed.

These concerns need to be addressed through the Stakeholder Engagement Plan.

Livestock

Very few households mentioned livestock farming as a primary economic activity in the Study Area. However, the field research programme identified the presence of many farm animals in the Project footprint. According to our calculations, 11500 farm animals live in the villages with priority 4 and 5. Most of these are chicken and poultry, goats, sheep and pigs (see Figure 6-49 Farm Animals in the Study Area (Source rePlan, 2015)). Farm animals provide households with basic goods for primary household consumption needs (e.g., eggs, milk, and meat). Occasionally, animals or animal products are sold in local markets.

Figure 6-49 Farm Animals in the Study Area (Source rePlan, 2015)



6.11.5.3 Artisanal Mining

Context

Gold panning, or artisanal gold mining, consists of extracting gold using mainly manual methods and simple tools. In Côte d'Ivoire, this activity has been practiced since the second half of the 18th century. The Baoulé Faafoués are believed to have started extracting gold from the Kokumbo Bocca 150 years ago. Prospective miners search for gold in quartz-bearing shale lands (Baoulé) and in detrital placers formed by decomposed shale (Sanwi, Yaourè, Akoué, Indénié, Baule).

Artisanal gold mining, originally practiced for the purpose of building non-transferrable community-based wealth (tribal or family wealth), has become a source of personal income in the Study Area as a result of a several factors and attracts an ever-increasing number of practitioners. According to estimates by the Ministry of Industry and Mines, the proliferation of artisanal gold mining affects 24 of the 31 regions of Côte d'Ivoire and is practiced by more than 500,000 people in rural areas.

In the Yaourè gold mine Project Area, evidence exists of gold panning activities allegedly dating back to the colonial period. According to elderly residents of Kouakougnano, locals mined gold in order to remit taxes to colonial authorities. The same sources indicate that industrial gold mining in the area began the late 1980s with the exploration, trenching, and coring and open pit mining activities of the BRGM Company, followed by the open pit and heap leaching conducted by the Compagnie Minière d'Afrique from 1993 to 2003.

Today, artisanal gold mining appears to be the main socio-economic activity in the Yaourè mining Project area. These activities have given rise to social and environmental impacts that are often challenging for local populations and administrative authorities to manage.

Geographic distribution

Artisanal gold mining in the project area commenced approximately 150 years ago, however commercial exploration activities have been conducted since 1935. Artisanal mining continues in several areas in and around the current Perseus exploration license area where the shallow gold bearing, mainly quartz veins may be accessed. The gold ore is mined through the small-scale surface stripping of exposed gold-bearing layers and through sinking of narrow vertical shafts to intersect the gold veins. This has led to the removal of shallow topsoil and gold bearing layers over large areas, and the creation of dangerous open shafts as well as minor stockpiles.

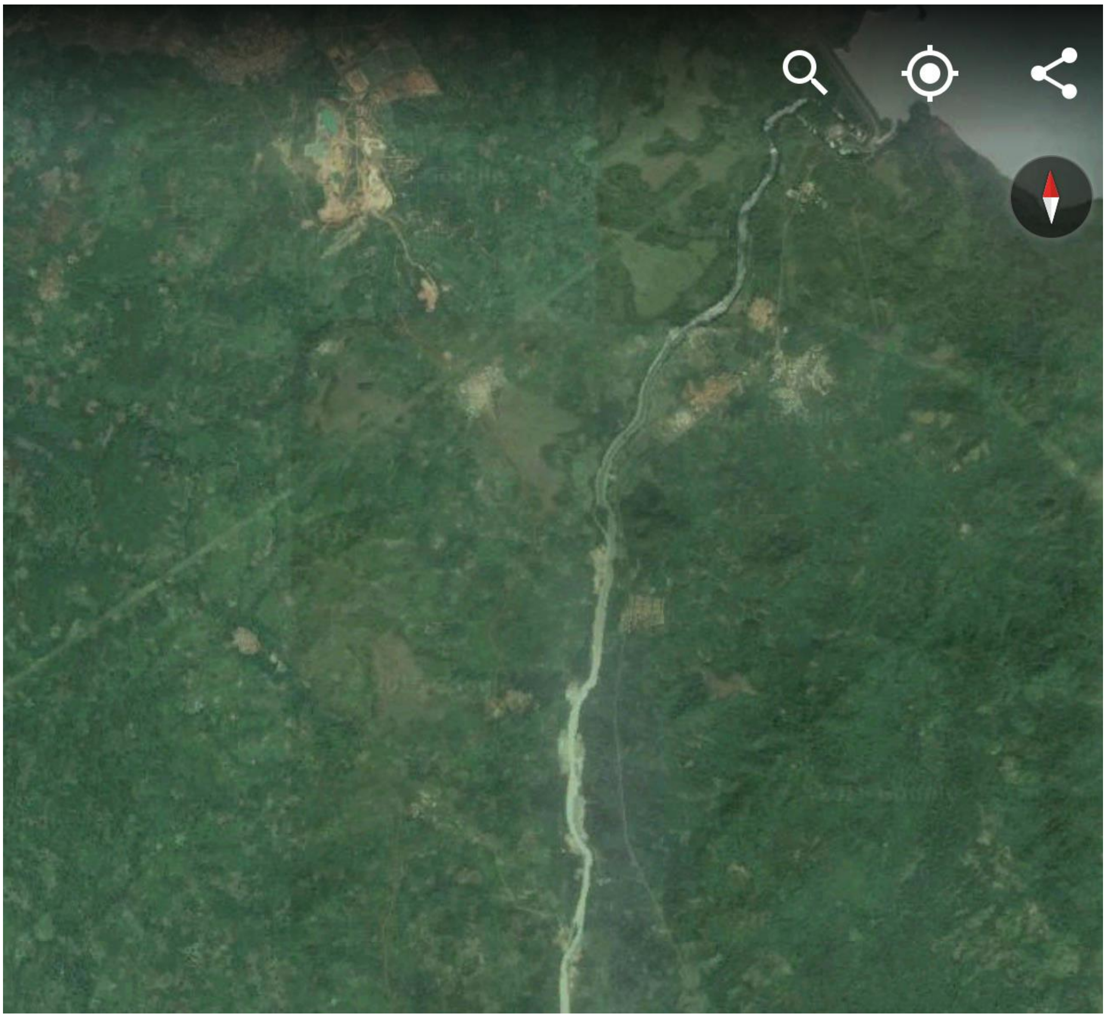
The Anti-Pollution Centre of Côte d'Ivoire (CIAPOL) has undertaken a study of artisanal mining activities in the Regions of Hire (Bonikro Mine), Kocoumbo (maybe Newcrest Exploration Permit), Oumé (close to Bonikro Mine), Yamoussoukro, Bouaflé and Angovia (Yaoure Mine) during October 2012. This has been supplemented with a survey by Perseus during November 2014 on the locations and numbers of artisanal miners in the Yaoure area. The mapping of artisanal mine sites was updated by rePlan in 2015, see Figure 6-60.

Artisanal miners migrate from one area in the exploration licence to another where the gold ore is most readily accessible. This is causing significant levels of environmental degradation, specifically to vegetation, soil and siltation of surface water resources. The impact of artisanal mining on surface water quality in terms of siltation (turbidity, suspended fines) is apparent from satellite imagery, see Figure 6-50. The open pits associated with the artisanal mining cause significant safety risks.

Descriptive findings from the CIAPOL study, 2012 stated that illegal artisanal mining activities are mainly carried out by immigrants rather than citizens of Côte d'Ivoire.

Artisanal activities in the Yaoure area are carried out through various methods from simple panning to using explosives, diesel driven crushers, extensive washing and use of chemicals such as mercury and reportedly also cyanide. However, no details are known.

Figure 6-50 Satellite image of the Project area, note the plume of suspended fines in the Bandama river downstream of artisanal mining sites



End of April – beginning of May 2015, Chinese and Burkinian artisanal miners were evicted by the Government from their quarries. Some of the camps and quarries were flattened (see Figure 6-52).

Figure 6-60 Artisanal mining activities in the Project area

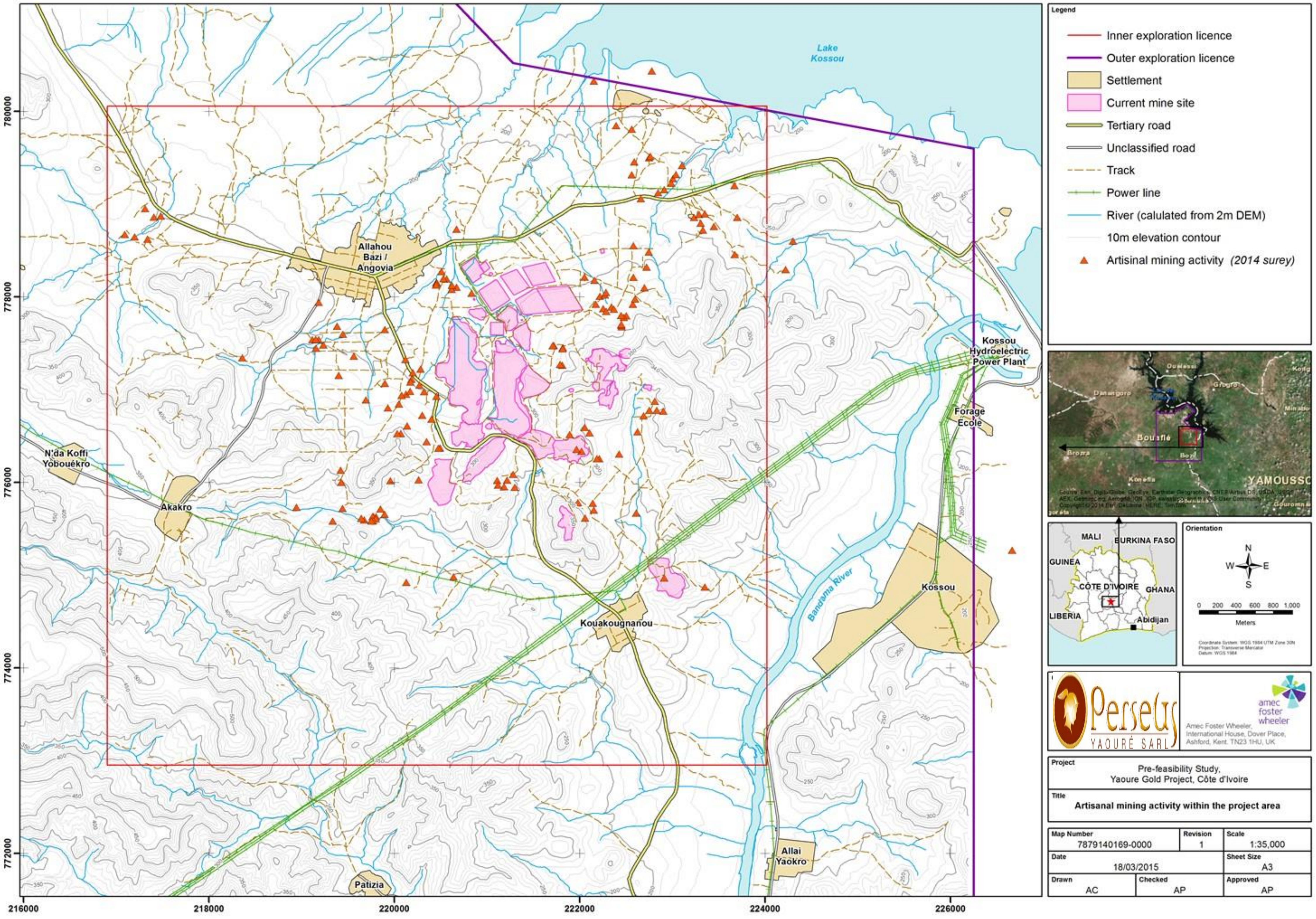


Figure 6-51 Update of the artisanal and Semi-Industrial Mining Camps in the Study Area (Source rePlan, 2015)

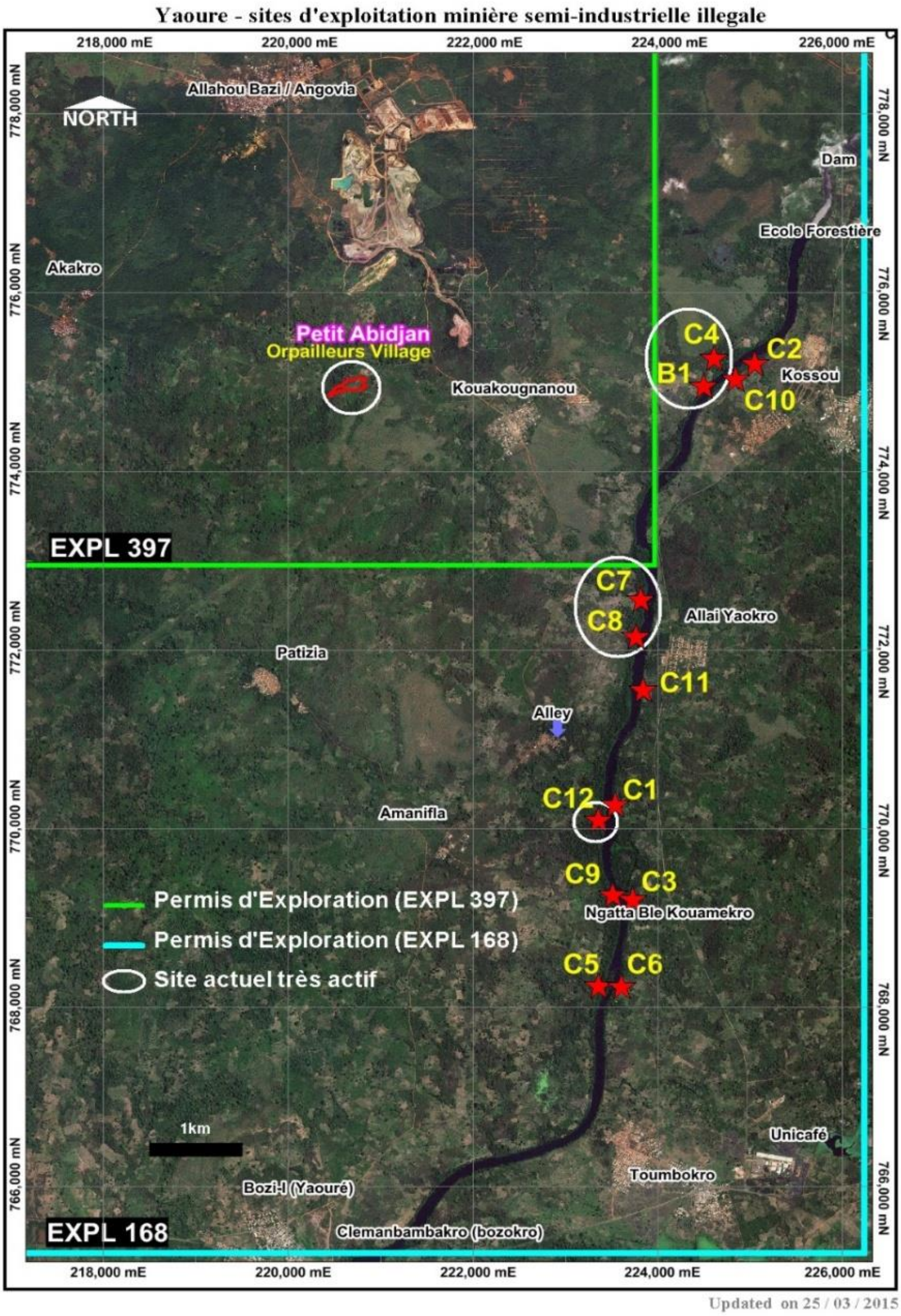


Figure 6-52 Former artisanal mining camp ("Petit Abidjan"), destroyed after eviction of the miners

Features of Gold Panning in the Project Area

<u>The sites and stakeholders</u>

Artisanal gold mining is widespread in the Study Area area. The most significant gold panning sites, in terms of size and number of gold panners, are located near the settlements of Kouakougnanou, Angovia, Allahou-Bazi, Alley and Patizia.

Although regulated by Mining Code Act No. 2014-138 (28 March 2014), artisanal gold mining in the Study Area area is carried out without government authorisation. In practice, the consent of a landowner, ability of the miner to pay the landowner for access, and their technical know-how are the only requirements of opening a gold panning site. The following information on artisanal mining activities was collected during interviews with landowners and miners, and, owing to reluctance among respondents to provide information on the proceeds of these unauthorised activities, statistical information on the production levels and revenues is unavailable.

To date, there are at least 17 landowners in the Study Area who, in the past five years, have transferred between 1 and 3 plots of land to individuals for the purpose of artisanal gold mining.

The gold-bearing formations subject to mining activities in the Yaourè gold mine Project area consist mainly of veins, natural deposits, valleys, and rivers beds (Bandama River and brooks).

In general, landowners, miners, and gold planners should be considered the principle operators in the artisanal gold mining sector of the Project area.

Landowners

Since land ownership and access is conferred by customary law, land administration is carried out by heads of lineages and families, often a Chief of Land, who authorises third parties to access their land holdings for the purpose of gold mining. The processes by which land rights may be transferred to third parties are described in Section 2.3.11.3. The Chief of Land may also perform the necessary sacrifices prior to any gold mining activities.

Mine operators

Mine operators are often wealthy individuals, often from Burkina Faso, living near the Study Area or in large cities such as Yamoussoukro and Abidjan. They receive authorisation from landowners to access land plots for gold mining purposes. The operator appoints a site manager who organises production their behalf. Principal features of the production process include recruitment and management of miners, purchase of mining equipment, supervision of the purchase of gold, health and safety on the gold mining site, in addition to other production processes. The site manager acts as an intermediary between absent mine operators and other industry players. If a mine operator possesses several sites, a coordinator is appointed to oversee the activities of several site managers.

The interviews indicate that artisanal gold mining in the Yaourè mining Study Area is controlled by three principal miners of Burkinabe origin who operate without official authorisation, though they are in possession of an agreement with the landowners.

Smaller-scale mining operations on land parcels within the Project Area are conducted by individuals working on their own behalf and perform the role of site manager described above. They sell their ore to gold wholesalers.

Gold panners

The term "gold panner" applies to all those who practice artisanal gold mining (mining and processing). They are the largest group and represent all sections of rural society. Gold panners work in teams. The composition of a team of panners depends on the type of gold formation under production. Extraction from gold veins may require only a team of diggers. In this case, stones are machine-crushed off site. Site visits accounted for 15 crushing machines in Allahou-Bazi/Angovia and 17 in "Petit Abidjan" (the largest gold mining site in the Study Area). The team may also consist of diggers and crushers. In this case, stones are ground on site manually with a hammer or a machine.

The mining of natural deposits requires a team of nearly ten people. The first group of workers generally consists of three diggers who extract ore from the pit by means of pulley or rope and bucket. This is a highly labour-intensive task performed exclusively by men that entails frequent risk of landslide. The second group of workers, consisting of two or three individuals, carries sand extracted from the mine to a water source where two or three women wash it. Representatives of the landowner whose role is to reduce the risk of theft supervise these workers.

Management of land, a gold production factor

Artisanal gold mining entails three important land management factors: payment for land access rights, payment of the costs of all the necessary sacrifices, and a commitment to sharing the gold profits with the landowner.

Land access right

This is a negotiated price between the mine operator (or anyone who wants to use a parcel for gold mining purposes) and the landowner. The amount depends on the size and estimated quality of the land plot. Miners in and around Kouakougnanou and Angovia have paid FCFA 200,000 to 750,000 for access, while access to the Petit Abidjan site was secured for FCFA 3,000,000. These prices, payable once, can be renegotiated and increased if the amount of land put under production increases. Finally, payment for access rights does not equate to a transfer of property rights.

Sacrifice costs

In African societies in general and in the Akan community in particular, any activity related to the mining of gold must be carried out with the consent of the gods who possess special concern for the precious metal. Sacrifices are therefore performed in order to obtain this consent and a blessing of protection for the duration of mining activities. A sacrifice may be renewed when an accident occurs or when gold production decreases "abnormally." The sacrifice typically entails one goat or ox, depending on the preference of the landowner, six bottles of wine, six bottles of beer, 20 litres of palm wine, and one rooster. These items may be substituted by a cash payment to the landowner, who alone is able to perform the sacrifice.

Landowner's rights

Consisting rights of the landowner primarily includes payment by the mine operator of FCFA 2,000 per gram of gold produced on the landowner's land. In addition, the transfer of land by the landowner to an individual establishes a relationship of mutual. To maintain this relationship, the mine operator provides periodic assistance to his "guardian" in different situations that may arise from time to time, including bereavements and celebrations, for as long as the land is under production.

Landowners are increasingly drawn by the available of ready cash to sell rights to their land plots, including cocoa and coffee plantations, to mine operators. In fact, 10 (83%) of 12 landowners interviewed said that it is more advantageous for them to transfer their land to gold panners than it is to use them for agricultural purposes.

Interviews and site visits indicate that small-scale, individual panners are very poor, and artisanal mining is not especially profitable. However, many are drawn to the activity as the only way to generate regular cash throughout the year. The gold price is fixed by the mine operators on a regular basis (between FCFA 10,000 and 15,000 during the surveys – March 2015).

Equipment used in artisanal gold mining activities

The various artisanal gold sites we visited are characterised by rudimentary mining and processing methods undertaken with rudimentary tools such as shovels, picks, hoes, buckets, and calabashes, sawn gas bottles, motorised pumps, hammers, torches, hurricane lamps, pulleys, and ropes. However, in some cases more modern equipment such as metal detectors and crushing machines are being introduced (see Figure 6-53).

Figure 6-53 Crushing machines and tools

Several types of inputs are used in artisanal gold mining activities in the Project area for both mining and processing purposes. The fact that gold panning is a clandestine activity makes it almost impossible to identify and assess the quantity of inputs used by gold planners. Some industry players reported they believe some panners are making use of cyanide in the gold production process.

6.11.5.4 Fishing

History of Fishing in the Project Area

Lake Kossou was created in 1971 following the construction of a hydroelectric dam on the Bandama River in Kossou, sub-prefecture of Yamoussoukro. The construction of the dam involved eight administrative districts and sub-prefectures:

- Béoumi, Bodokro, Tiébissou, Sakassou and Yamoussoukro on the left bank; and
- Bouaflé, Gohitafla and Kounahiri on the right bank.

The creation of the lake resulted in the immersion of 201,400 ha of forest, savannah, plantations and villages. It also resulted in the submersion of nearly 20,000 ha of coffee and cocoa plantations.

The damming of the Bandama led to the displacement of over 100,000 people and the abandonment of many previously inhabitable sites. In response, the government has declassified part of the Sassandra classified forest in favor of some resettled and equipped volunteers. To compensate for economic losses and shock suffered by the population, the government of Côte d'Ivoire initiated an integrated development project in the Lake region, the Bandama Valley Development Project (AVB), which established 120 new villages and implemented an agricultural development programme focused on crop intensification.

To diversify the income sources of affected populations, between 1972 and 1977 the AVB established a programme to train locals on fishing techniques and equipment monitoring and installation (Fabio et al. 2002). Thanks to the water impoundment system provided by the Kossou Dam, which covers 1,750 km², fishing, in the past not widely practiced in Baoulé country, experienced a considerable upturn from 1969 onwards, thanks to the efforts of 400 fishermen. However, newly trained and resettled fishermen soon abandoned their new vocation and returned to agricultural production, drawn to the profitability of coffee and cocoa. The rapid transition away from fishing in favour of cash crops created opportunities on the lake for migrant fishermen. It was from this period that the occupation of the Kossou water stream by Malian fishermen (Bozo and Somono people) began. Their presence lasted until the expulsion of all foreign nationals from the lake in 2001.

Types of Fish Caught

The following fish species are commonly caught in the area: Nile perch, carp, catfish, electric catfish, and bagrid catfish. Harvested fish tend to be small because most fishermen cannot access deeper waters and fear hippos. Figure 6-54 below, shows a bagrid catfish caught by a fisherman in Lake Kossou.

Figure 6-54 Bagrid Fish caught in Lake Kossou (Source 2D Consulting, 2015)

Type of Fishing Gear

Commonly used fishing gear includes: gillnets, meshes, "papolo" traps, lines, "Djoba" big nets, Tonkine canes, palm wood, and canoes. This gear is typical of traditional fishing styles practiced in the Study Area. In general the lake's water levels do not suit industrial fishing techniques. The figure below shows the typical fishing gear used by fishermen in Lake Kossou.

Figure 6-55 Typical Fishing Gear Used in Lake Kossou (Source 2D Consulting, 2015)

Mapping of the Main Fishing Areas

Our field survey shows that 21 households of 380 practice fishing, or, 5.5%, despite water levels and the fact that the population has no real tradition of fishing. Fishing has become a significant source of income in the Study Area since the construction of the Kossou Dam. As a result of the expulsion of foreigners from the lake in 2001 following conflict between locals and Guinean fishermen of the Bozo ethnic group, Côte d'Ivoire citizens once again constitute the main national group on the lake. However, since 2007, some Malian and Burkinabe fishermen have returned to the area, settling in fishermen camps 1 and 2.

Table 6-63 below shows the distribution of households practicing fishing in Study Area-affected villages.

Table 6-63 Distribution of Fishing Households by Village (Source 2D Consulting, 2015)

Villages	Frequency
Akakro	0%
Allahou-Bazi	28.5%
Alley	4.7%
Amanifla	4.7%
Angovia	0%
Campament des pecheurs 1	24%
Kossou	24%
Kouakougnanou	4.7%
N'da Koffi Yobouekro	4.7%
Patizia	4.7%
Total	**100%**

Table 6-63 indicates that the majority of fishermen (28% of fishing households) live in the village of Allahou-Bazi. Fishermen Camp 1, an appendage of Allahou-Bazi, hosts 24% of the fishing households. These households fish in Lake Kossou. On the other hand 24% of fishing households live in the village of Kossou and operate on the nearby Bandana River.

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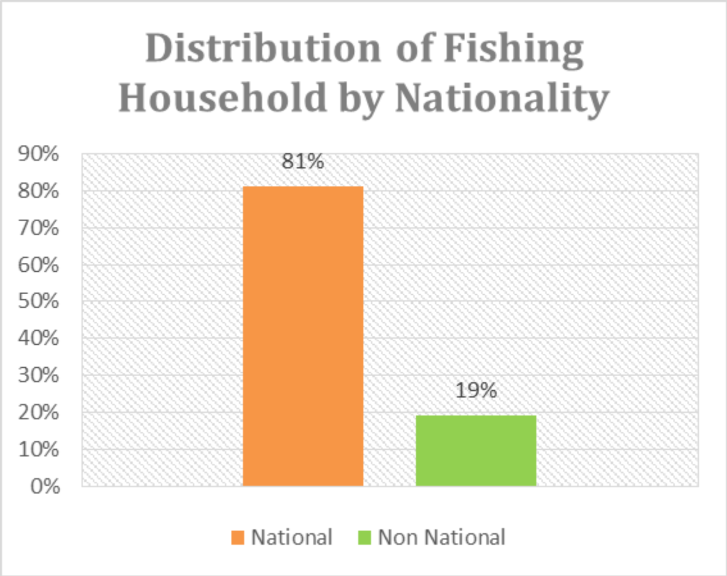
Fishermen in the Study Area are mainly from Côte d'Ivoire (81% of households). All other nationalities together account for 19% of fishing households. This distribution of fishermen by nationality appears in the figure below:

Figure 6-56 Distribution of Fishing Households by Nationality (Source 2D Consulting, 2015)



Results of Interviews and Focus Groups

Field survey reports show that fishermen do not belong to any organisation. They receive authorisation to fish in Lake Bouaflé by the Prefect of Bouaflé and pay a monthly licensing fee of FCFA 3,000 to the Water and Forests Department.

Fishermen sell fresh fish at lakeside to women who resell them I local markets. Fish is sold fresh and dried. Large fish are sold fresh at FCFA 2,000 per kilogram. Women sell fish in quantities of three or four, depending on their size, at FCFA 5,000. Women practice fish smoking in addition to selling fish.

Figure 6-57 Fish drying oven and dried fish in the Study Area (Source 2D Consulting, 2015)

The fishermen interviewed reported that in good times fishing generates incomes varying between FCFA 5,000 and 10,000 per month. Fishing is practiced for personal consumption and sale, or most often both. Only 5% of households practicing fishing sell their entire catch. Table 6-64 below shows breakdown.

Table 6-64 Breakdown of fishing production by use (Source 2D Consulting, 2015)

Purposes	**Frequency**
Personal consumption	28.57%
Sale	4.76%
Consumption and sale	66.67%
Total	**100%**

Fishing Criticality

Surveyed fishermen indicate dissatisfaction with the quality of fishing gear, which they deem generally unsuitable. They are also concerned about their inexperience, the result of lack of quality training. Furthermore, village consultations also evidenced a generalised concern with decreasing fish stocks.

Project-Related Concerns

The concerns raised by fishermen with respect to the implementation of the Yaourè Project are related to fears of increased water pollution in Lake Koussou and the Bandama River and a resulting decline in fish populations. As many fishermen are principally farmers, they worry that fish stock depletion will ultimately result in a loss of land.

Fishermen also fear an increase traffic accidents and a general rise in insecurity in the Project area. Though they hope the Project will remedy the issue of youth unemployment, however, the majority of fishermen are not concerned about Yaoure Project because, in general, they have grown accustomed to mining in the area.

6.11.6 Vulnerability and Poverty

Identification of Vulnerable Population

In order to identify the Vulnerable Population in the Study Area, the research team has created a methodology based on the Sustainable Livelihoods Framework that assesses the level of vulnerability of each household surveyed according to the five assets: Economic, Social, Physical, Human, and Natural. A detailed description of the methodology as well as the indicators used to arrive at the assessment of vulnerability is presented in **Error! Reference source not found.**G.

The methodology assigns a score of Vulnerability to each household. All households and communities whose final vulnerability score falls within the first two quintiles (i.e., <40/100) automatically qualify for special assistance under the socio-economic management plans.

In addition to households and communities, this SEBS identifies individuals and groups in the study area that are significantly more vulnerable than the general population, whether due to a specific circumstance, or as a result of a broader range of factors.

Women - Due to the nature of domestic relations women are likely to be reliant on male members of their household for financial support; as such, they are less likely to have access to financial assets. In addition, in many settlements women may be unable to partake in communal decision-making processes and are reliant on male members of the household to share information with them. Within this group, female-headed households may be specifically vulnerable, as they are less likely to have any form of representation at the settlement level.

Illegal Workers (Artisanal Miners) – Those whose livelihoods depend on illegal economic activities might have their income streams interrupted and / or face marginalisation within local traditional communities.

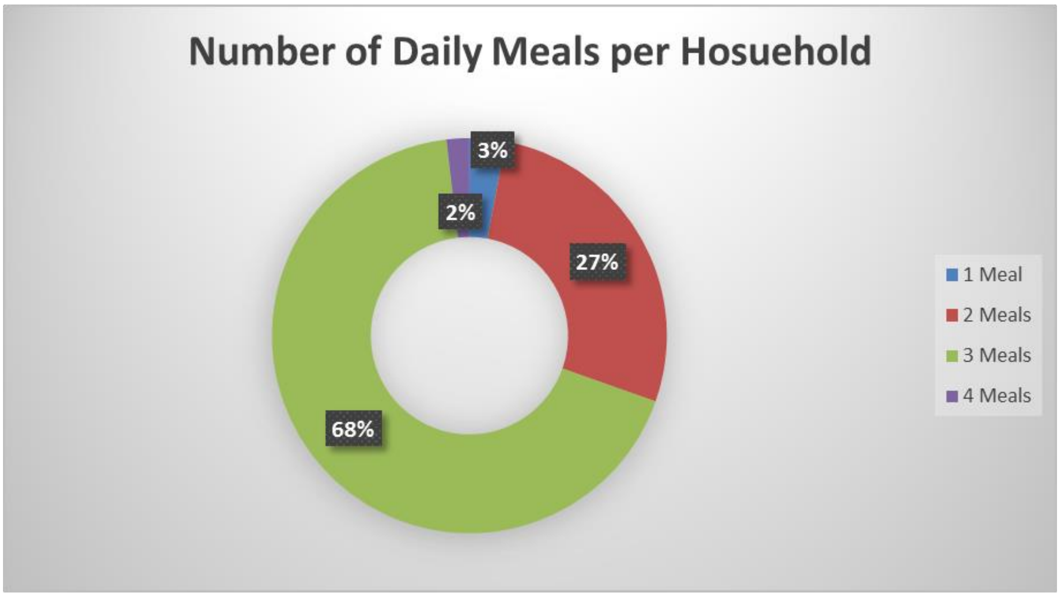
Foreigners and Minority Groups - Some groups may face marginalisation within local traditional communities and suffer reduced access to healthcare, education, civil rights, credit, and other services. In most cases minority groups practice religions and languages that are not indigenous to the Study Area. If minority and migrant groups are non-Côte d'Ivoire citizens, they may not claim ownership rights to community land.

Retired/Elderly/Disabled – Retired/elderly members of the community are likely to possess minimal incomes and are more likely to have reduced physical or mental capacity to cope with changes to their environment. Those who lack physical mobility or who have mental health issues are especially vulnerable to change and unable to participate in decision-making processes. This category includes individuals suffering from drug or alcohol addictions.

Issues about Food Security

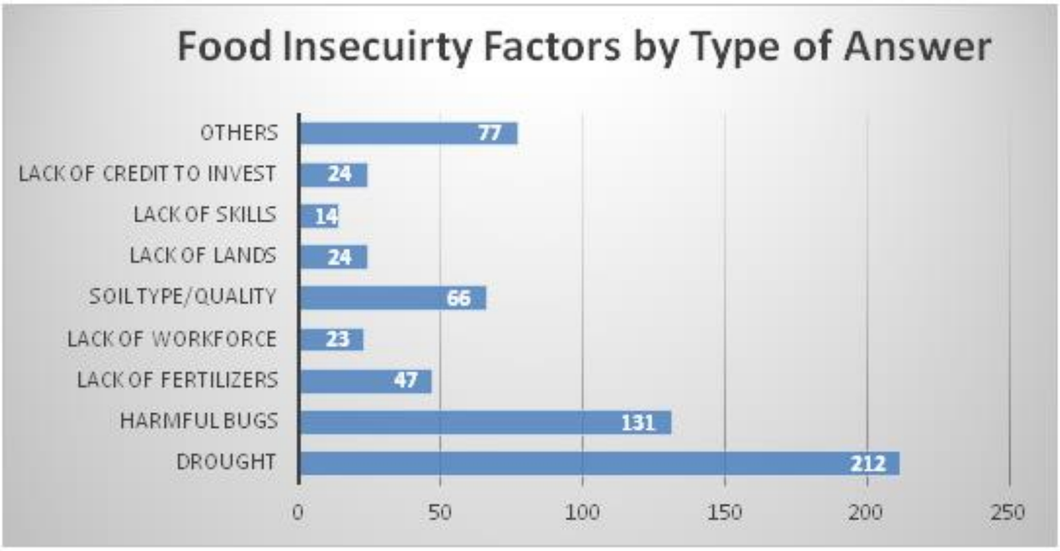
The majority of households in the study area prepare family meals between 2 and 3 times a day (average of 2.6 meals a day, rePlan 2015). However, there are significant differences within the survey sample: 3% of households reported an ability to secure only one daily meal. 2% of households have access to more than 3 meals a day (see Figure 6-58).

Figure 6-58 Number of daily meals per household (Source rePlan, 2015)



Surveyed households were asked to specify which factors are most important in preventing failed harvests and food shortages in the Study Area. Figure 6-59 illustrates the results of the surveys. The most oft-cited community concern is related to rainfall, which in a majority of cases is the principle means of crop irrigation in the Study Area. Poor soil quality (prevalence of "coteaux" and "bas-fonds"), epidemics caused by harmful insects and the unavailability of pesticides and fertilisers to improve agricultural production are among the most-cited factors undermining agricultural yields in the Study Area.

Figure 6-59 Food insecurity factors (Source rePlan, 2015)



6.12 Cultural Heritage

6.12.1 Baseline Methodology

In IFC PS 8, Cultural Heritage is defined as follows:

> *1. Tangible forms of cultural heritage, moveable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values;*
>
> *2. Unique natural features or tangible objects that embody cultural values, such as sacred groves, rocks, lakes, and waterfalls; and*
>
> *3. Intangible forms of culture to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.*

The Yaoure Gold Environmental and Social Scoping Report (AMEC, 2014) established that the Yaoure North are regarded as the native population. The people of Yaoure migrated there from the current Ghana in search of gold and agricultural land most likely in the 18th century. They are led by a chief and have patrilineal relationships with strong patrilocality. Land and control determines political power and importance and therefore access and ownership to land is of significant importance.

However, in the context of Côte d'Ivoire, the Yaoure rural communities conform to a national, and indeed regional West African, traditional cultural setting. The national traditional cultural setting is shared by many of the population, and includes traditional practices and cultural norms associated with a tribal social heritage, such as collective attachment to natural resources in distinct habitats, customary cultural institutions and ceremonial and spiritual practices.

This traditional cultural setting, which is widely shared by many of the population of Côte d'Ivoire, does not identify Yaoure communities as representing a distinct minority culture. Communities that might be defined as 'indigenous' are therefore not present at Yaoure, although it is apparent that heritage values among the nearby communities are expressed through traditional knowledge and practice, but less so in material form.

There is a relative absence of documented or recorded data on the earlier history and archaeology of the Cote D'Ivoire interior, although there is a known prehistoric presence. There is currently little to suggest that archaeology makes a significant contribution to a current understanding or expression of the cultural heritage of Côte d'Ivoire. However, as the 2D report observes, the site was occupied at different periods throughout history, and cultural heritage remains at the site provide archaeological (prehistoric) knowledge that can be considered valuable within IFC PS 8.

It was on this basis that this assessment has followed a methodology based on the guidance set out in IFC PS 8.

It should be noted that based on the findings of the social and Cultural Heritage baseline, applying the criteria set out in IFC PS 7 it has been concluded that there are no indigenous peoples in the Project area.

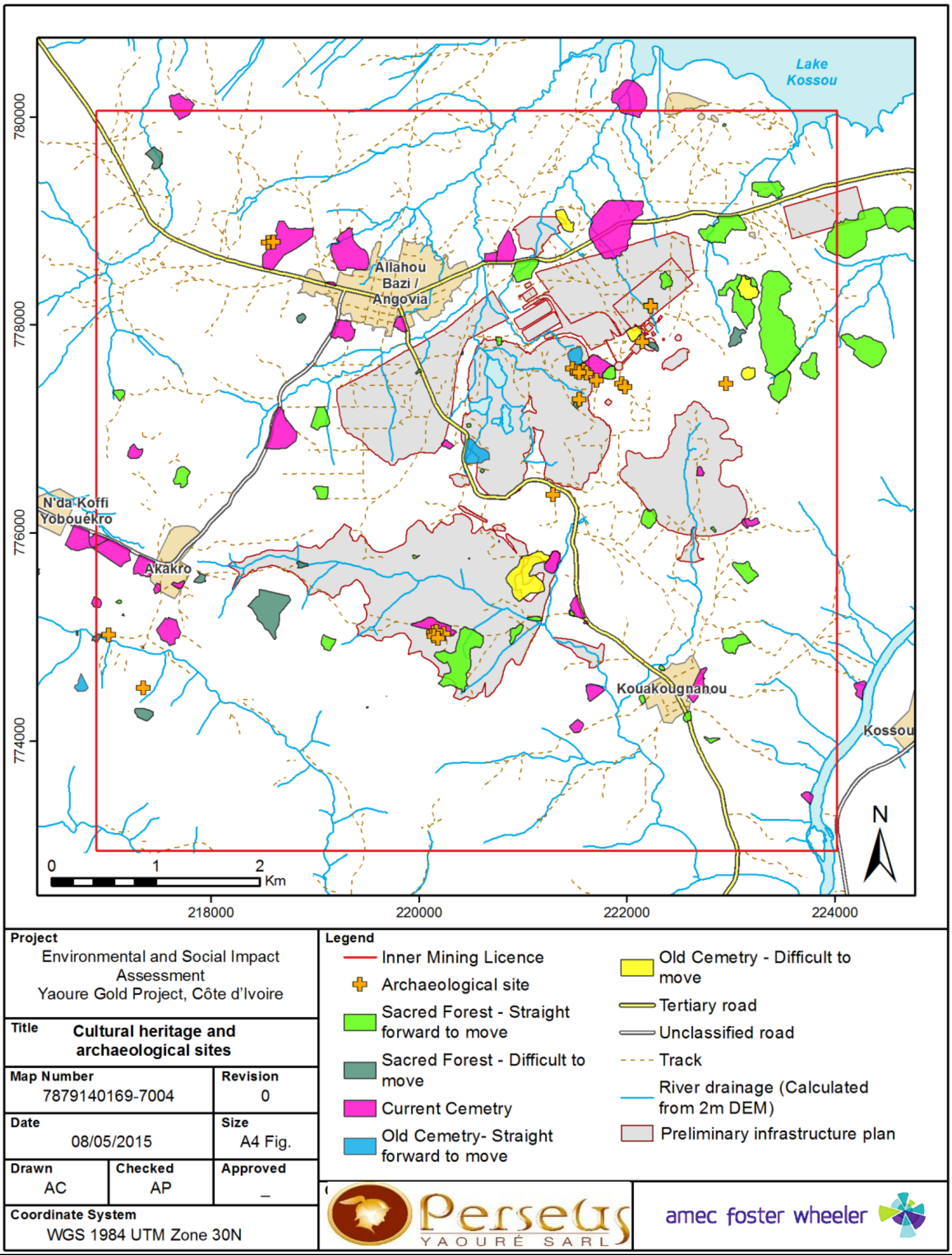
6.12.2 Baseline Results

6.12.2.1 Overview

An archaeological and cultural heritage study was undertaken at the Yaoure Gold Project by 2D Consulting (**Error! Reference source not found.**). The study drew upon existing reports and studies of the area in addition to a field visit, from 14 to 18 February 2015, carried out by cultural heritage specialists from 2D Consulting. The field visit consisted of a site survey of 13 areas proposed for development, as well as surveys and interviews with local leaders, landlords, guardians and chiefs. The key aims of the site visit were to:

- Undertake a survey of areas to be affected by the proposed development;
- Establish the presence and location of any archaeological remains on the site;
- Evaluate the importance of any remains on the site; and
- Confirm the accuracy of existing maps of cultural heritage and sacred sites.

Figure 6-70 Locations of archaeological and cultural heritage finds



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amec foster wheeler

Full details and results of the survey are found within the full report in **Error! Reference source not found.**. The current section presents a summary and the key findings.

6.12.2.2 Material Culture

Several of the areas proposed for development were found to contain small amounts of scattered archaeological cultural heritage. The finds included fragments of pottery, iron slag indicating ancient metal working, hatchets, and a polishing stone. With the exception of TSF2 and TSF3 (see

Figure 4-1), finds were located in areas which were heavily disturbed by previous mining activities or construction work (including artisanal gold mining and road working).

As a consequence, the potential for further in-situ archaeological cultural heritage was considered to be low in most areas.

TSF3 was not selected as a development site and is not considered further in this report.

The site of TSF2 contained a large amount of pottery fragments towards its western half between a sacred forest and an old cemetery (previously the site of the Kouakougnanou Village (GPS Coordinates: 30N x=0220 205; y=0775 058). The area was found to be undisturbed by modern activity, and there is the potential for further buried archaeological cultural heritage.

6.12.2.3 Sacred Sites

A number of sacred sites are present within the area of the mining licence. The location and number of which are accurately recorded on existing mapping (see

Figure 6-70), and were confirmed during the field visits through surveys with members of the five affected villages.

The sacred sites include cemeteries and sacred forests.

- **The old cemetery:** the old cemetery is closely linked to the social and religious life of the population, and is considered a place of memory where the current populations can maintain relationships with the spirit of the dead and the ancestors through ritual. It is noted as occupying the former site of the village Kouakougnanou (known as 'Clonou' before WWII). The old cemetery is distinguished from the current cemetery by the fact that it is no longer used for burial, although it is still a place to worship the dead.

- **Sacred Forests:** Forests are places of worship for deities and include elements such as boulders, hills, rivers etc, in which the spirit of divinities can be found, that can provide protection against malicious spirits, prosperity, fertility and invisibility from enemies.

The location of the sites is illustrated within the 2D report in **Error! Reference source not found.**.

6.12.2.4 Intangible Cultural Heritage

In addition to including natural features which embody cultural values as discussed above, the IFC PS8 includes the following intangible assets within its definition of cultural heritage:

> *"[...] certain instances of intangible forms of culture to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles."*

From the data collected from existing reports, studies and during the field visit, Amec Foster Wheeler is not currently aware of any instances of intangible cultural heritage.

6.13 Community Health & Safety

This section of the report provides a community health and safety baseline of the potentially affected communities in the Project Area. The baseline study follows International Finance Corporation guidance (IFC Performance Standards and Guidance Notes, 2012) to meet expectations outlined in IFC Performance Standard 4. Performance Standard 4 (Community Health, Safety and Security) recognises that projects can increase community exposure to risks and impacts, and the importance of identifying groups that may be vulnerable to these exposures. In terms of post-conflict areas such as Côte d'Ivoire, it is important to identify sensitive local situations and scarcity of local resources.

The community health and safety baseline draws on information from publically available literature, other discipline studies presented in this report, an in-house household survey and focus group interviews completed by rePlan in February 2015 to provide general and specific characteristics of community exposure to risks and impacts and groups that may be vulnerable to these exposures.

6.13.1 Objectives

The overall objective of the community health and safety baseline study is to identify the major risk and challenges in the potentially affected populations and communities. Specific objectives are directly related to IFC PS 4 performance standards:

- Identify existing environmental, social and cultural conditions that could influence community health and safety in Côte d'Ivoire;
- Identify baseline levels of infrastructure and equipment design and safety performance in Côte d'Ivoire;
- Identify baseline level of hazardous materials management and safety in Côte d'Ivoire;

- Identify existing health conditions that might be affected by project related environmental and social risks, including existing community exposure to water-borne, water-based, water-related, and vector-borne disease, and communicable diseases; and any vulnerable groups who exhibit higher sensitivity to such exposures; and

- Identify existing security conditions in Côte d'Ivoire that might be related to provision of security personnel at the project site.

6.13.2 Potentially Affected Populations

The potential affected populations lie within the social impact area of influence (see The Error**! Not a valid bookmark self-reference.**3 illustrates the three areas of influence that have been defined for the purposes of the social impact assessment:

- Area of Direct Influence;
- Area of Indirect Influence; and
- Area of Regional Influence.

Each area corresponds to different types of social issues and requires specific types of baseline data to evaluate these issues and implement appropriate mitigation and benefit enhancement measures. Physical displacement impacts will be realised for any impacted land or property located within the Area of Direct Influence,

Importantly, these areas of influence straddle two different departments: Bouafle Department and Yamoussoukro Department. This must be taken into account in the stakeholder engagement activities.

Finally, the Project will have some national level significance, particularly in terms of government revenues.

Figure 1-3 for an overview and Section 6.11 for details). The potentially affected population is grouped by proximity to the project area:

- Area of Direct Influence;
- Area of Indirect influence; and
- Area of Regional influence.

There are four communities within the area of direct influence, that is, within the exploration lease:

- Akakro;
- Angovia;
- Allahou Bazi;
- Kouakougnanou;

There are 17 communities within the indirect area of influence:

- Allai Yaokro;
- Alley;
- Amanifla;
- Begbessou;
- Bokasso;
- Bozi;
- Camps 1, 2 and 3 Fisherman;
- Kami;
- Kossou;
- N'da Koffi Yobouekro;
- Ngatta Ble Kouamekro;
- Toumbokro;
- Patizia; and
- Small Hamlet.

These communities' proximate location to the proposed mining activities and infrastructure (Figure 1-2) means residents will potentially face profound effects as a result of mining activities. For this reason, a comprehensive baseline was prepared including a sample household survey, focus groups and key informant interviews.

6.13.3 Methods

The community health and safety baseline was developed based on IFC Guidance Note 4. Specific methods are detailed below.

6.13.3.1 Community Health

For the purposes of this study, the scope of community health includes general health conditions and community exposure to disease. This is supplemented with contextual information related to environmental, social and cultural conditions in the country.

General Health Conditions

A literature review identified publically available international, national and regional data on existing environmental, social and cultural conditions in Côte d'Ivoire. Sources of local and regional health data collected by health agencies were not identified.

Local data was collected through focus group interviews with health centre and clinic staff, and a household survey.

Community Exposure to Disease

A literature review identified publically available international and national data on disease incidence and prevalence in Côte d'Ivoire. Sources of local and regional health data collected by health agencies were not identified.

Local data was collected through focus group interviews with health centre and clinic staff, and a household survey. A household survey was conducted by rePlan during February 2015 in the Direct Area of Influence and Indirect Area of Influence. All communities within the Direct Area of Influence were subject to the household survey. In the indirect Area of Influence, 7 communities participated in the household survey, and those results are assumed to represent the health status of the 17 communities within the defined area. There were no representatives interviewed from the following communities in the Indirect Area of Influence so no specific data exists for these villages and hamlets:

- Allai Yaokro;
- Begbessou;
- Bokasso;
- Bozi;
- Camps 2 and 3 Fisherman;

- Kami;
- Ngatta Ble Kouamekro;
- Toumbokro; and
- Small Hamlet.

The heath data survey collected self-reported health data. Interviewees were asked to report number of new cases of named disease per household over the previous twelve months in order to derive incidence-based data. Prevalence-based data was not collected at the household survey level. The data collected included communicable diseases that could be affected by the Project or which might affect availability of labour pool or productivity of the workforce. The data were not verified against local or regional health data because these were unavailable for review.

Environmental Health

Baseline reports from other disciplines were reviewed to identify any potential environmental exposures through Ecosystem Services (ES) pathways that may affect community health and safety. Some environmental data was collected through the household survey.

Community Health Services

A literature review identified publically available international, national and regional data on health services. Local data was collected through focus group interviews with health centre and clinic staff, and a household survey.

6.13.3.2 Community Safety

For the purposes of this study, the scope of community safety includes infrastructure and equipment design and safety; hazardous materials management and safety; emergency preparedness and response; and road traffic safety.

6.13.3.3 Infrastructure and Equipment Design and Safety

Infrastructure and equipment design and safety standards are established internationally, nationally and by industry. Information on infrastructure and equipment design and safety in Côte d'Ivoire was gathered through a web search for publically available literature. Specific focus was provided to literature describing any inclusion of industry best practice within internationally published comparative reports.

6.13.3.4 Hazardous Materials Management and Safety

Hazardous materials management and safety standards are established internationally and nationally. Information on infrastructure and equipment design and safety in Côte d'Ivoire was gathered through a web search for publically available literature. Whether or not a country is signatory to a convention or not is an indicator of the countries awareness and commitment to hazardous waste management, therefore, specific focus was provided to international agreements with possible signatory status for Côte d'Ivoire (e.g., 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade), and internationally published reports on health and safety in Côte d'Ivoire.

6.13.3.5 Emergency Preparedness and Response

Emergency preparedness and response standards are established internationally and nationally. A web search was conducted for publically available information on emergency preparedness and response standards in Côte d'Ivoire. Specific focus was provided to international agreements and internationally published reports on emergency preparedness and response in Côte d'Ivoire.

6.13.3.6 Road Traffic Safety

A web search was conducted for publically available information on road traffic safety.in Côte d'Ivoire. Specific focus was provided to internationally published reports. The rePlan household survey (2015) also collected data on road traffic injuries.

Results from the Traffic Study (**Error! Reference source not found.**) have also been taken into account, however, it should be noted that the focus of the Traffic Study is different and not directly related to Community Health and Safety (see Section 6.10).

6.13.3.7 Community Security

For the purposes of this study, the scope of community security includes personal safety and security. Specific issues addressed include gender-based violence and integrity of private security personal.

6.13.3.8 Personal Safety

Information on personal safety and security was gathered through a web search for publically available literature. Specific focus was provided to internationally published reports.

6.13.3.9 Security Personnel

Security personnel standards are established internationally and nationally. Information on security and security personnel in Côte D'Ivoire was gathered through a web search for publically available literature. Specific focus was provided to international agreements with possible signatory status for Côte D'Ivoire, and internationally published reports.

6.13.4 Community Health and Safety Baseline Conditions

Community health and safety in Côte d'Ivoire is set against a backdrop of social, economic and political recovery after 15 years of civil conflict and, in 2011, a post-electoral crisis.

6.13.4.1 Community Health

The 2012-2015 national health development plan set the goal of creating a high quality health system to attain the best possible health for all citizens while underpinning potential for growth and development of the country (WHO 2014). However, the current health situation in Côte d'Ivoire means the country is unlikely to achieve health related Millennium Development Goals in 2015. The major challenges to be addressed are:

- Reduction of maternal and infant mortality;
- Improvement of health care coverage; and

- Development of health research.

Community health is discussed below in terms of Côte d'Ivoire and the potentially affected populations using publically available data and the data collected in the project household survey. Note that the most recent published data available from World Health Organisation (2014) for Côte d'Ivoire is for 2012.

6.13.4.2 Life Expectancy and Mortality

Life expectancy at birth in Côte d'Ivoire is 53 years (WHO 2014). This is below the WHO African Region average (58 years) and below the global average (70 years) (WHO 2014).

Under-five mortality rate is 108 per 1000 live births for both sexes in Côte d'Ivoire (WHO 2014). This is higher than the WHO Africa Region average (95 per 1000 live births) and higher than the global average (48 per 1000 per live births) (WHO 2014).

The adult mortality rate is calculated based on the probability of dying between 15 and 60 years per 1000 population. The adult mortality rate for males in Côte d'Ivoire is 409 per 1000 population. This is higher than the WHO Africa Region average (343 per 1000 population) and higher than the global average (187 per 1000 population). The adult mortality rate is generally lower for women globally, including in Côte d'Ivoire. The adult mortality rate for females in Côte d'Ivoire is 292 per 1000 population. This is lower than the WHO Africa Region average (298 per 1000 population) and higher than the global average (124 per 1000 population) (WHO 2014). Based on the proportional differences between adult mortality for females and males, women in Côte d'Ivoire are generally more vulnerable (ratio of 0.96) than other women within the WHO Africa region (ratio of 0.87) and more vulnerable than women globally (ratio of 0.66).

6.13.4.3 Communicable Disease

Communicable diseases are the major cause (69%) to years of life lost in Côte d'Ivoire (WHO 2014). This is typical for the WHO Africa Region. With an incidence of 120 cases per 1000 person-years, malaria is the major contributor to morbidity and mortality rates. Tuberculosis is a national concern and incidence of reported cases increased from 2006 to 2011. In 2010, incidence of reported cases was 106 cases per 100,000 of population. Côte d'Ivoire reported 3.7% HIV/AIDS prevalence in the general population for 2011-2012. In terms of children, malaria (16%); other diseases (15%); and acute respiratory infections (15%); are the top three causes of deaths in children under 5 (WHO 2014).

Locally, in the direct and indirectly affected areas, diarrhoea and dysentery were the most common communicable self-reported diseases occurring in the potentially affected populations in 2014 (Table 6-65). Cumulatively, the local data (2014) is generally similar to the WHO (2014) national data discussed above, suggesting that the self-reported health status of people resident in the project area is generally representative of the general population in Côte d'Ivoire. Local health workers also verified this in general terms during focus interviews, indicating that malaria, respiratory infections and diarrhoeal symptoms are the predominant illnesses presented at the health centres/hospitals.

Table 6-65 Incidence of Select Communicable Diseases in Area of Direct and Indirect Influence of the Project (2014) based on self-reported data

	Incidence* (new cases per 100,000-person years)		
	All (Area of direct and indirect influence)	**Area of Direct Influence**	**Area of Indirect Influence**
Water-related diseases			
Diarrhoea	2 694	1842	3856
Dysentery	829	449	1346
Typhoid	389	314	490
Giardia	233	0	551
Food-borne illnesses			
Worms	25	45	0
Lung disease			
Tuberculosis	130	45	245
Pneumonia	233	180	306
Vector-borne disease			
Malaria	19 533	16 801	22 399
Yellow Fever	104	135	734
Scabies	207	135	306
Sexually transmitted diseases			
Hepatitis B	0	0	0
HIV/AIDS**	0	0	0
Syphilis	0	0	0

Notes: *based on new cases during the past 12 months
**health centre workers reported prevalence of HIV/AIDs; however, none were self-reported, indicating that sexually transmitted diseases were likely unreported during the household survey.
Source: Household Survey (Amec Foster Wheeler 2015)

Based on data from the household survey, in general, communicable disease is higher in the area of indirect influence than in the area of direct influence. For all reported communicable diseases except Giardia, the average ratio of incidence between the Direct Area of Influence and the Indirect Area of Influence is 2.8. That is, in general, the individuals in the Indirect Area of Influence have nearly 3 times the rate of new cases of communicable disease than individuals in the Direct Area of Influence. This is possibly explained by the existing support provided by Perseus as an international mining company to potentially affected persons in the Direct Area of Influence. This support includes access to a health centre in Angovia with reduced consultation fees (FCFA 100) when compared to government provided health care in the indirect area of influence (FCFA 300), as described during focus group interviews (2015).

Water-related diseases

Based on household survey results, diarrhoea appears endemic throughout the area and was self-reported in all communities except Camp 1 Fisherman. Typhoid was also self-reported in all but one community (Akakro) surveyed.

Water-borne diseases (e.g. diarrhoea, typhoid), are related to poor quality drinking water and sanitation. There is increased water-borne and water-related diseases in the Indirect Area of Influence (3856 new cases per 100,000 person years) than in the Direct Area of Influence (1842 new cases per 100,000 person-years), suggesting that potentially affected populations in the Direct Area of Influence have improved sanitation and drinking water when compared to the Indirect Area of Influence.

Food-borne illness

Food-borne illnesses are a result of poor personal hygiene and unsanitary conditions. Worms were self-reported in the Direct Area of Influence but not in the Indirect Area of Influence.

Lung Diseases

Lung diseases affect the underprivileged and are exacerbated by poor air quality, malnutrition, overcrowded living conditions and lack of access to health facilities. Based on self-reported incidences, incidence of tuberculosis is higher in the Indirect Area of Influence (245 new cases per 100,000 person-years) than in the Direct Area of Influence (45 new cases per 100,000 person-years) suggesting living conditions and access to health facilities are improved in the Direct Area of Influence. Incidence was limited to select and few communities within the potentially affected populations. Self-reported pneumonia was reported in communities that did not report tuberculosis

Vector-borne Disease

Vector-borne diseases are related to environmental factors. Mosquitoes breed in stagnant water and are often carriers of malaria.

The health centre in Angovia reported 40% of clinic consultations are related to malaria, which is aligned with the national and household data. Data from the household survey (2015) indicates that malaria was contracted by persons who used mosquito nets all the time, some of the time and none of the time, indicating that mosquito nets use is not a determining factor in malaria transmission. Exposure to malaria carrying mosquitoes may occur during the day and not just at night for those without malaria nets. This suggests that communities are likely to have numerous bodies of stagnant water throughout the areas where people complete their daily activities, at home and at work.

Scabies infestations are caused by mites that live under the skin. Scabies is spread by prolonged direct contact with skin or through shared bedding, towels and clothing of an infested person. This kind of contact may occur in household or other settings where frequent physical handling of people or contaminated articles occurs. Scabies was self-reported in three adjacent villages: Patkia, N'dakoffi Yoboueko and Akakro. These communities straddle the Direct Area of Influence and Indirect Area of Influence.

HIV/AIDs

Health professionals report that HIV/AIDS is commonly regarded as an illness caused by witchcraft and sorcery. Sexually transmitted diseases were not self-reported during the household survey; however, health care workers indicated these diseases are prevalent in the potentially affected populations during focus interviews.

The Kossou health centre reported 1.5% pregnant women tested positive for HIV/AIDs, in 2013. The Angovia health centre reported 15% of pregnant women attending the clinic in 2014 were diagnosed with HIV/AIDs, suggesting that HIV/AIDs is likely higher in the directly affected project area than the national average and was underreported in the household survey.

6.13.4.4 Non-communicable diseases

Non-communicable diseases are responsible for 22% of years of life lost. This is typical for the WHO Africa Region. Cardiovascular diseases (high blood pressure affects 33.4% of the population); oral and dental diseases; drug addiction, tobacco use (13%) and cancer in women (incidence is 87 per 100 000) are national concerns.

The household survey (2015) focused on common diseases of concern in Côte d'Ivoire and/or mining communities in general. Table 6-66 demonstrates that diabetes and cardio-vascular disease was reported in the direct and indirect areas of influence. These results are not aligned with the national health data, for example, interviewees self-reported much higher incidence of diabetes than cardiovascular disease. Local medical staff did not verify findings or provide health data.

Table 6-66 Incidence of Select Non-Communicable Diseases in Project Area (2014) Based on Self-Reported Data

	Incidence* (new cases per 100000-person years)		
	All (Area of direct and indirect influence)	**Area of Direct Influence**	**Area of Indirect Influence**
Cardiovascular disease	259	270	240
Diabetes	415	630	120
Stunting	0	0	0
Stroke	0	0	0

Notes: *based on new cases during the past 12 months
Source: Household Survey (rePlan 2015)

Table 6-66 demonstrates that non-communicable diseases associated with mining activities (cardiovascular disease and diabetes) reported higher incidence in the direct area of influence than in the indirect area of influence.

6.13.4.5 Community Health Services

National Context

Pre-conflict, Côte d'Ivoire enjoyed a comprehensive health infrastructure system and services with 293 public health facilities operating throughout the country. Post-conflict, 51 were operational while 242 had been deemed non-functional due to destruction and looting. Many health services personnel had left the country during the conflict period and at its end, thirty physicians served the 3 million population (Rocker at al. 2009).

Post-conflict, the 2007 National Health Plan outlined a basic package of essential services to be rolled-out across the country. Essential services were determined to be:

- Maternal and newborn health
    - Antenatal care;
    - Labour and delivery care;
    - Emergency obstetric care;
    - Postpartum care;
    - Newborn care;
- Child heath
    - Expanded programme on immunisation;

- Integrated management of childhood diseases;
- Infant and young child feeding;

- Reproductive and adolescent health
  - Family planning;
  - Sexually-transmitted infections;
  - Adolescent health;
  - Communicable disease control;
  - Control of STIs/HIV/AID;
  - Control of tuberculosis;
  - Control of malaria;
  - Control of management of other diseases with epidemic potential;
- Mental health;
- Emergency Care; and
- AIDS/HIV.

The roll-out included rural areas which were underserved prior to the conflict period. The basic packages were implemented with support from international and national nongovernmental organisations (Rocker at al 2009).

Universal Health Care Law was passed in March 2014. The government will progressively implement a universal health care scheme over the period 2015–19. The government will gradually increase the number of beneficiaries and the services. The health care scheme will focus on reimbursement of part of the expenditure for pharmaceuticals, ambulatory and hospital services. Decisions have yet to be made on the population and services covered, however, the government plans to partially subsidise the poorest households (IMF 2014).

Today, in 2015, health infrastructure in Côte D'Ivoire is comparatively good with a better equipped health sector, when compared with other countries in West Africa (Heitz Tokpa, Kaufmann and Zanker, no date).

Local Health Care Services

There are two rural health care centres in the areas of direct and indirect influence: a government funded health care clinic in Kossou and mining company funded health care clinic in Angovia.

Kossou Health Centre

The Kossou Health Centre is a government funded health centre, currently providing general medical services, including the basic health package of services described above. The health centre includes a laboratory, pharmacy, radiography and a hospital ward with 17 beds. The centre has an ambulance and a dedicated ambulance driver. Consultations at Koussou health center is FCFA 300.

Health care workers report the health centre is in a state of disrepair. Three of the five buildings are functional. The centre includes a functional toilet.

Angovia Health Centre

The Angovia Health Center services the villages of Angovia, Allahu-Bazi, Kouakougnanou, Akakro, N'dakoffiyobouékro, Kami, Bocassou and camps, and Goundeni. The rural health centre focuses on general medical consultations, prenatal and postnatal care; vaccinations and HIV / AIDS. Patients requiring other services are referred or transferred to hospitals in Bouafle or Yamoussoukro.

The Angovia Health Centre has no ambulance and no running water. The clinic is currently operating with one birthing box, 3 inpatient beds and 2 cribs but has two non-functional birthing boxes and one non-functional bed. Health centre staff indicate the center is in an advanced state of degradation with patients being released earlier than standard due to risk of infection.

There are two state qualified nurses, one midwife, and three ward assistants on staff. Consultations with one of the two nurses cost FCFA 100. Midwifery services are free. Patients supply any necessary equipment (e.g., needles) and prescription drugs.

Use of Health Care Services

In addition to the two rural health centres in the project area, some households in the project area travel to government funded hospitals in Bouafle and Yamoussoukro, other rural health centres outside of the defined areas of influence, and traditional healers for medical care (see Table 6-67).

Table 6-67 Percent **of households reporting health care facility attended in the area of direct and indirect area of influence, by village**

	Bouafle Hospital	Yamoissou-kro Hospital	Angovia Health Centre	Kossou Health Centre	Other rural health Centre	Traditional healer
Direct Area of Influence						
Angovia	1%		96%	3%		
Kouakougnanou	3%	6%	9%	23%	60%	
Akakro	5%		95%			
Allahou Bazi	3%	3%	89%	6%		
Indirect Area of Influence						
Alley		5%		70%	20%	5%
Amanifla	10%	5%			85%	
Fisherman's camp 1			70%	20%	10%	
Kossou		3%	2%	92%	3%	
N'da Koffi Yobouekro			100%			
Patizia					100%	

The mining company funded health care clinic in Angovia is used by around 90% households in the direct area of influence, except for Kouakougnanou where households reported attending an 'other rural health centre.' The Angovia Health Centre is also used by households in the indirect area of influence, mainly from Fisherman's Camp 1 and N'da Koffi Yobouekro.

'Other rural health centres' are predominantly used by households in Kouakougnanou (60%), Amanifla (85%) and Patizia (100%). The 'other rural health centres' category is likely to represent the health centre in Bozi, Bouafle.

Traditional healers are present in the area. In the populations surveyed, 5% of households in the hamlet of Alley reported attending traditional healers.

Limitations to Use of Health Care Services

Few households (34% and under) reported no limitations to health care services as is demonstrated in Table 6-68. Cost was reported as the main limitation to health care in both the direct and indirect areas of influence. Distance was reported as a secondary issues in Kouakougnanou and Akaro in the direct area of influence. Table 6-68 also shows that distance was reported as a secondary issue in rural areas of the indirect area of influence. Quality of service and group pressure appear to be of low (<15%)

importance. Households were able to choose more than one limitation to health care services; total percentages do not necessarily add to 100%.

Table 6-68 Percent of households reporting specific limitations in accessing health care in the direct and indirect area of influence, by limitation and village (Source: Household Survey)

	Cost	Distance	Quality of service	No limitations	Group pressure	Other
Direct Area of Influence						
Angovia	53%	0%	11%	24%	3%	14%
Kouakougnanou	57%	43%	0%	11%	0%	3%
Akakro	62%	24%	3%	16%	11%	0%
Allahou Bazi	54%	0%	3%	31%	7%	11%
Indirect Area of Influence						
Alley	40%	35%	5%	30%	10%	0%
Amanifla	50%	20%	0%	25%	5%	0%
Camp 1 Fisherman	40%	10%	0%	10%	0%	40%
Kossou	63%	0%	2%	34%	5%	2%
N'da Koffi Yobouekro	45%	40%	10%	30%	10%	0%
Patizia	69%	26%	0%	18%	3%	3%

6.13.5 Environmental Health

6.13.5.1 Sanitation

The household survey indicated that 65% of households have no formal sanitation system, indicating the sanitation conditions are extremely poor. Regular pit latrines were reported by 7% of households. Improved pit latrines were reported by 21% and 7% reported having flush toilets within their household. The remaining 7% report use of their neighbours' toilets.

WHO (2014a) reports that sanitation facilities are inappropriately utilised and this constitutes a major risk for the outbreak of various diseases caused by environmental factors. This suggests that even if improved sanitation facilities are installed, they may not be used appropriately and therefore be in poor sanitary condition and a source of water-related communicable disease.

6.13.5.2 Access to surface and groundwater for human and agricultural use

Potable water is mainly obtained from boreholes or wells (76%). During the groundwater monitoring programme bacteria, including E Coli, were detected in boreholes in Akakro, due to poor sanitation conditions upstream to the boreholes. Surface water resources are the drinking water supply for 14% of households.

Reports from other disciplines suggest that livestock do not share drinking water sources but run-off from livestock waste could be impacting drinking water quality.

6.13.6 Community and Road Safety

Injuries account for 9% of years lost (WHO 2014). This is representative of the WHO Africa Region. Note that this figure must not be confused with the traffic accident data received from the Department for Infrastructure and Transport (DIT, see **Error! Reference source not found.** and Section 6.10.3) that refer to the frequency of accidents rather than the years lost.

Serious traffic accidents occur regularly throughout Côte d'Ivoire. Hazardous driving conditions are caused by unsafe road conditions, unskilled drivers, and poorly maintained and overloaded vehicles. In general, speed limits, lane markings, and signals are not respected, and drivers tend not to yield to pedestrians or bicyclists (Government of United States of America. 2014).

Data from the household survey indicates that traffic injuries are more frequent in the Direct Area of Influence (0.007 injuries per person-year) than in the Indirect Area of Influence (0.005 injuries per person-year). However, exploration traffic has not been involved in accidents, according to infomation received from Perseus.

6.13.7 Infrastructure and Equipment Design and Safety

In country infrastructure and equipment design and safety standards do not meet international standards. UNESCO (2010) indicated that after the military-political crisis, Côte d'Ivoire is at a technological crossroads and renewed efforts need to be placed on engineering, particularly in regards to international standards.

In a country summary, UNESCO (2010) reported engineering education in Côte d'Ivoire standards are poor. Côte D'Ivoire reported zero engineers receiving tertiary education within the country between 1999 and 2006 (UNESCO 2010); however, civil engineering education is provided by the National University in Abijan and several private universities. The National University develops senior engineers and technicians. The private universities train technicians.

There is evidence that the government of Côte d'Ivoire is facilitating the improvement of construction standards in general. The government has improved the regulatory environment by streamlining the construction permit process by creating 'onestop shop' facilities (The World Bank 2015a). In 2015, Côte d'Ivoire rated within the top 10 top improvers worldwide for implementing regulatory reforms related to construction and business (The World Bank 2015b). The government of Côte d'Ivoire has initiated policies to encourage innovation. Other steps forward include plans to invest heavily in engineering education, improve environment for women engineers and improve engagement with engineering organisations (UNESCO 2010).

6.13.8 Hazardous Materials Management and Safety

Hazardous waste management and safety policies in Côte d'Ivoire meet international standards; however, lack of funds and lack of commitment to implement policies has meant that hazardous waste continues to be dumped with industrial waste or is left outside of landfills (UNEP, undated). The development and current status of hazardous waste management in Côte d'Ivoire is described below.

Côte d'Ivoire is signatory to the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (UN 2015), and the 2001 Stockholm Convention on Persistent Organic Pollutants (UN 2015). Côte d'Ivoire has also ratified the White Lead (Painting) Convention, 1921 (No. 13) and Benzene Convention, 1971 (No. 136) (ILO 2012); and these chemical hazards are the only named controlled substances in the occupational health and safety regulation (ILO 2013).

After an incident in 2006, when hazardous waste from a sea bearing vessel was dumped in Abidjan in 2006 (Basel Convention undated), the UNEP Post Conflict and Disaster Management Branch and Basel Convention (undated) announced the implementation a project to strengthen capacity of Côte d'Ivoire to monitor and control transboundary movements of hazardous chemicals. The project was implemented in three phases: (1) a gap analysis; (2) development of recommendations for the coordinated implementation of the three chemicals and waste conventions; and (3) education of enforcement agencies, including environmental authorities (convention focal points). The third phase consisted of a series of seminars and was completed in 2011 (Basel Convention, undated).

Hazardous waste policies have existed in Côte d'Ivoire since 2009, including provision for hazardous waste storage facilities. In a recent needs assessment by Global Partnership for Waste Reduction, UNEP (undated) reported that funds are currently lacking for safe disposal, awareness among waste generators is inadequate and there is limited enforcement of environmental policies. As such, hazardous waste is often found alongside municipal solid waste or disposed outside of landfills (UNEP undated). WHO (2014a) describes poor management of household, industrial, biomedical and other types of waste, indicating that chemical exposures may exist for the general population.

6.13.9 Emergency Preparedness and Response

Emergency services (police, fire, ambulance) are available only in Abidjan and larger towns. Emergency services are reported to be unreliable, that is, response times do not meet international standards. Smaller towns usually have no ambulance service available; however, ambulances may be dispatched from larger towns to smaller communities (Government of United States of America 2014).

Côte d'Ivoire's Ministry of Environment, Water and Forests is responsible for emergency preparedness and response policies in Côte d'Ivoire. The country is signatory to the Hyogo Framework for Action (HFA) 2005-2015 (Preventionweb undated), which is based on five priority action commitments:

- Ensure that disaster risk reduction is a national and a local priority with a strong institutional base for implementation;
- Identify, assess and monitor disaster risk and enhance early warning;
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels;
- Reduce underlying risk factors; and
- Strengthen disaster preparedness for effective response at all levels.

A literature search identified limited information on emergency preparedness, response and emergency services. Based on updates provided at the Hyogo Framework for Action (HFA) 2005-2015, provisions for emergency preparedness and response appear to have been planned but not yet implemented. Lack of health care infrastructure and efficient and responsive services likely limits operational capacity. As such, emergency response appears to be limited to international humanitarian emergency relief (e.g., United Nations Office for the Coordination of Humanitarian Affairs (OCHA) 2011).

A separate Emergency Preparedness and Response Management Plan has been developed as part of this ESIA (see **Error! Reference source not found.**), that will be implemented when the Project commences and will be periodically reviewed and updated.

6.13.10 Community Security

The government of Côte d'Ivoire has made considerable progress restoring peace and security since 2011 (OSAC 2014); however, the country remains in a post-conflict scenario. With incomplete disarmament and weak law enforcement (UNSC 2014, 2015), violent crime, including sexual violence remain major community safety risks.

Côte d'Ivoire is signatory to the Organisation of African Unity Convention for the Elimination of Mercenaries in Africa but has not yet ratified the convention (OHCHR 2015). That said, mercenaries were reported in the country during the post-electoral crisis in 2011 (Transparency International 2012).

6.13.11 Violence

A key security challenge is the proliferation of small arms and light weapons throughout the country (Transparency International 2012, UNSC 2015). In the past, quantities of small arms have not been monitored or controlled at the government, industrial or community level (Transparency International 2012). This suggests there are unknown quantities of small arms and light weapons within the general population. This proliferation is cited as the reason for the high occurrence of violent crimes in the country. Violent crimes include armed robberies, looting and racketeering, including by the armed forces and other armed parties (UNSC 2014).

The Small Arms Survey (de Tessieres 2012) identified perpetrators of armed violence to be young men between 25 to 35 years old. The principal victims of armed violence are also within this group. The Small Arms Survey (de Tessieres 2012) reported that since medical care is expensive and prohibitive for some victims, injuries can have long-terms physical and psychological after-effects that jeopardise the economic survival of the victim's household. Religious and ethnic differences within the population are reported to exacerbate violence in Côte d'Ivoire (UNSC 2015).

On a local scale, violence including violence against women and children were reported in the household survey (2015). In relative terms, there were more violent acts in general and against children household within the Indirect Area of Influence than in the Direct Area of Incidence. In contrast, there were more violent acts against women reported within the Direct of Area Influence than in the Indirect Area of Influence. Of the 7 acts of violence (0.003 per person-years) reported by surveyed households in the Direct Area of Influence, 3 were against women and 2 were against children. Of the 8 acts of violence (0.005 per person-years) reported in the Indirect Area of Influence, none reported were against women and two were against children.

6.13.12 Sexual Violence

UNSC (2015) reported that women and children (girls and boys) are at risk of sexual violence. This risk is associated with concentration of ex-combatants. These risks are greatest in the western and northern parts of the country, which includes Bouaflé and the Project area. UNSC (2014) indicates there are possibly 60,000 to over 100,000 ex-combatants in the country.

UNSC (2015) lists the armed forces and ex-militia groups in Côte d'Ivoire as parties credibly suspected of committing or being responsible for patterns of rape and other forms of sexual violence in situation of armed conflict. In the post conflict era, UNSC (2015) reported ex-combatants who have been reintegrated into the transport sector can pose a risk to women and girls who are reliant on motorcycle, bus and taxi services. Ex-combatants employed as bus and taxi drivers in Bouaflé have been involved in robbery and rape at gun point (UNSC 2015). Ex-military personnel can pose a risk when participating in the security service industry. In 2014, the Government of Côte d'Ivoire announced a strategy to combat gender based violence by ex-combatants and military personnel. Reporting by UNSC (2015) suggests that implementation has been a challenge.

6.13.13 Private Security Services

Private security services are currently regulated in Côte d'Ivoire. They are overseen by the Minister for Domestic Security, supported by the Minister for Defence and the Minister for the Economy and Finance, as well as the Director for Domestic Security and the National Police (OCHR 2015).

In legislation, private security activities are limited to providing security of persons and property, including the transport of funds, money, important objects and documents. Security personnel are prohibited from participating in a labour conflict; gathering information on political, religious or trade union opinions; becoming involved in the activities of the administrative police or investigative police; participating in operations aimed at maintaining public order at political, sport, social, traditional, cultural or religious events; and escorting persons. Regulations discourage former members of the military forces or the police to act as managers or employees of private security companies. In Côte d'Ivoire members of the police, gendarmerie and armed forces can act as owners, managers, or employees of a private security company a year after the date of cessation of their functions or activities. It is prohibited for managers or employees of a private security company having served in the military or paramilitary forces to announce or declare that fact publicly (OCHR 2015).

Security companies are allowed to be armed and to possess weapons, including firearms. At the same time, companies may only be "authorised to use stun bombs, clubs, rubber-bullet-firing firearms, pepper sprays and tear gas". Personnel of companies transporting money are specifically obliged to "carry a first or fourth category firearm" (subject to authorisation) to exercise their activities (OCHR 2015).

Monitoring is carried out by the Minister for Domestic Security and the law describes in details the process of inspections. In Côte d'Ivoire, private security companies are requested to submit regular (quarterly and annual) reports to their licensing agencies and monitoring bodies (OCHR 2015).

During the post-electoral crisis in 2011, some private security companies were accused of providing assistance to the regular armed forces (Transparency International 2012), suggesting that, historically, there has been a risk potential for coercion. The new legislation and regulation mitigates this risk.

6.13.14 Conclusions

Côte d'Ivoire is a country in post-conflict recovery. Infrastructure, access to health services, environmental and health regulation, and health status remain at low standards. Communicable disease is responsible for 69 per cent of lives lost in disease in Côte d'Ivoire and principally linked to poor drinking water quality, poor sanitary conditions and lack of funds to access to health services. Malaria and water-borne diseases are the most prevalent in the country and in the Direct Area of Influence and

Indirect Area of Influence. Communicable diseases appear more prevalent in the Indirect Area of Influence than in the Direct Area of Influence suggesting that current mining activities have led to improved sanitary conditions and drinking water sources in the Direct Area of Influence, which is the exploration lease area. In contrast, non-communicable diseases appear more prevalent in the Direct Area of Influence than in the Indirect Area of Influence, suggesting that mining activities may have influenced lifestyle and health.

Personal safety and security risks are present in Côte d'Ivoire, including the area of Project influence. On a personal security level, the most prioritised general safety concern is violent crime that is associated with the proliferation of small arms and light weapons within the general population. Women and children face a high incidence of sexual and gender-based violence, principally by ex-combatants. On a commercial level, the security services industry is newly regulated and includes violence prevention measures that discourage ex-combatants and military personnel from participating in the industry.

7 IMPACT ASSESSMENT METHODOLOGY

7.1 General

The ESIA is not an isolated event of reporting but a process that serves two functions:

- To provide the basis for decision-making, by the authorities, Perseus and affected stakeholders on the environmental and social acceptability of the Project; and

- To provide input to the Project design as it evolves, on an iterative basis.

An environmental or social impact is defined as any change to the biophysical or social environment, positive or negative, that wholly or partially results from a Project activity or associated processes or facilities. Activities can be classified into routine, non-routine (but planned) and non-routine (un-planned incidents). Incidents can be classified into unforeseen events (accidents) and natural events beyond design criteria (e.g. storm or seismic events with a frequency/intensity higher than the design criteria used in the Project). Incidents are better assessed for impact significance using probabilistic and risk analysis as there is no guarantee that the event will occur within the timeframe of the Project. The prevention and mitigation of incidents are therefore addressed in a separate section (Section 8.11.4) and in the Emergency Preparedness and Response Plan (**Error! Reference source not found.**).

The methodology used by Amec Foster Wheeler follows standard procedures; definition of issues and impacts, followed by determining the significance of the impacts inclusive of the proposed mitigation measures included in the Project design.

The impact assessment is carried out for the unmitigated and mitigated impacts. The effectiveness of the mitigation measures is assessed by the reduction in significance of the impacts.

7.2 Assessment of Physical Impacts

In order to (i) identify potential impacts on the bio-physical environment that may occur as a result of the Project activities being undertaken, (ii) differentiate between those impacts that are insignificant (i.e. can be sustained by natural systems) and those that are significant, and (iii) develop effective mitigation measures, the following steps are taken:

- Determine the sensitivity of the receptor(s);

- Determine the magnitude of a potential impact before mitigation;

- Calculate the product of these two parameters to generate the significance of a potential impact before mitigation;
- If required, develop measures to reduce the significance of the impact, following the mitigation hierarchy[6]; and
- Re-assess the significance of the impact after mitigation measures and determine whether mitigation measures are sufficient.

The assessment of magnitude and significance of potential (unmitigated) impacts is an important step in the ESIA process and interaction with the Project's engineering team, as it guides the Project improvement process by focusing on the impacts with high significance, and helps in prioritising mitigation measures. It is important to bear in mind that the potential impacts are not predicted Project impacts but describe a situation in which the mitigation measures described in this ESIA and in the Management Plans are not in place. The impacts that are expected if the Project is implemented with all mitigation and enhancement measures properly implemented are described in the subsections "Post-mitigation/enhancement impacts" for each specialist area.

The following sections of the ESIA are structured in line with this approach and reflect the Project optimisation process of the ESIA and Project engineering teams.

The terms "receptor sensitivity" and "magnitude" and "significance" of impacts are further defined in Table 7-1 to Table 7-4.

[6] Mitigation hierarchy: avoid, minimise, mitigate, restore, compensate.

Table 7-1 Definitions of sensitivity levels of receptors

Sensitivity	Description
Low	Areas already subjected to significant degradation Non-designated or locally designated sites/habitats Non-sensitive receptor with regards to the impact type (e.g. noise receptors)
Medium	Partially degraded area Regionally designated sites / habitats Regionally rare or endangered species Moderately sensitive receptor with regard to the impact type
High	Nationally or internationally designated sites/habitats Species protected under national or international laws / conventions High sensitivity with regard to the impact type

Table 7-2 Definitions of magnitude levels of impacts

Magnitude	Description
Minor	Reversible Duration < 2 years Will not cause any material change to the value or function of the receptor Emissions comply with regulations Emissions contained within footprint Local disturbance
Moderate	Potentially irreversible Duration > 2 and < 10 years Causes a change in the value or function of receptor but does not fundamentally affect its overall viability Emissions comply with regulations Emissions reach outside Project footprint Local/Regional disturbance
Major	Mainly irreversible Duration > 10 years Causes a significant change in the environment affecting the viability, value and function of the receptors Emissions do not comply with regulations Emissions reach outside Project footprint and may extend to national transboundary influence

The significance of the impact is calculated by multiplying the assigned values for magnitude of the potential impact and the sensitivity of the receptor to generate an evaluation matrix.

Table 7-3 Evaluation matrix for environmental, social and health impacts

			Sensitivity of Receptors		
			1	2	3
			Low	Medium	High
Magnitude	1	Minor	Negligible	Low	Medium
	2	Moderate	Low	Medium	High
	3	Major	Medium	High	Critical

The significance of the impact can be summarised in terms of numerical values as shown in the significance table below.

Table 7-4 Numerical ranking and verbal category of impact significance

Numerical impacty ranking (impact magnitude x receptor sensitivity)	Verbal category of impact significance
0-1	Negligible
2	Low
3-4	Medium
6	High
9	Critical
+	Denotes overall positive

7.3 Assessment of Biodiversity Impacts

The assessment of impact significance for biodiversity elements is a combination of the consequence of the impact occurring, and the probability that the impact will occur. This approach is slightly different to the general methodology, as it provides more details into the impact assessment process, such as including the probability of an impact occurring and the expected impact extent. The criteria and scores used in the calculation of biodiversity impact significance are included in Table 7-5.

Table 7-5 Criteria used to assess biodiversity impact significance

Criteria	Score	Description
Duration	1 = Short term	Possible to immediately or within a short period of time mitigate / immediate or fairly quick progress with management implementation <2 yr
	2 = Medium Term	Impacts reversible within the Life of Mine +2 to 13 yrs
	3 = Long Term	Impacts will only cease after the operational life +13 yrs
	4 = Permanent	Long term, beyond mine closure or irreplaceable
Extent	1 = Localised	Localised to specific area
	2 = Confined to site	Confined to site
	3 = Wider area of Influence	The extent of the impacts will affect the wider area of Influence
	4 = National / International	Importance of the impact is of national and or international importance
Magnitude	1 = Low	Minor deterioration Nuisance Will not cause any material change to the value or function of the receptor Emissions comply with legal limits Emissions contained within footprint
	2 = Minor	Moderate deterioration, partial loss of habitat / biodiversity/ social functions or resources, Emissions at times exceed legal limits Emissions reach outside project footprint
	3 = Moderate	Reversible although substantial illness, injury, loss of habitat, loss of resources Notable deterioration of functions Impact on biodiversity Causes a change in the value or function of receptor but does not fundamentally affect its overall viability Emissions regularly exceed legal limits Emissions will affect the wider region
	4 = High	Mainly irreversible Causes a significant change in the environment affecting the viability, value and function of the receptors Substantial impact on biodiversity Death/ loss of receptors Emissions do not comply with regulations, Extinction of Red List species
Sensitivity	1 = Low	Areas already subjected to significant degradation Non-designated or locally designated sites/habitats Non-sensitive receptor with regards to the impact type (e.g. noise receptors) No vulnerable communities

	2 = Moderate Low	Partially degraded area Sensitive receptors present Small number of vulnerable communities present
	3 = Moderate	Regionally designated sites / habitats Regionally rare or endangered species Moderately sensitive receptor with regard to the impact type Some vulnerable communities present
	4 = High	Nationally or internationally designated sites/habitats Species protected under national or international laws / conventions High sensitivity with regard to the impact type High number of vulnerable communities present High dependency
Likelihood	1 = Unlikely	Low probability of occurrence with the implementation of management measures
	2 = Possible	Possible that impact may occur from time to time
	3 = Likely	Distinct possibility that impacts will occur if not managed and monitored
	4 = Definite Likelihood	Impacts will occur even with the implementation of management measures

The different scores are then used to assess the significance rating. A significance rating for each impact has to be reached by taking consideration the likelihood, duration, extent, magnitude and sensitivity ratings. The significance rating has to be calculated in line with these findings. The formula to use to assign a significance class:

Significance = (duration + extent + magnitude) x sensitivity x likelihood

This will lead to a significant rating and score as follow indicated in Table 7-6.

Table 7-6 Significance rating score

Score	Significance Class
3 to 45	Negligible
46 to 90	Low
91 to 135	Medium
136 to 192	High

7.4 Assessment of Social, Socio-Economic and Cultural Heritage Impacts

The assessment methodology for socio-economic impacts is different from the methodology used for biophysical impacts in that it is qualitative rather than quantitative. This is because, with certain exceptions, social impacts can be expected to be:

- Multi-directional, in that the same project impact will be negative for some people and positive for others;

- Subjective, in that the analysis of impacts is based in part on stakeholders' own perceptions of change, rather than on the crossing of scientifically established quantitative thresholds;

- Complex and mutually reinforcing, in that they relate to the whole of a project rather than its component parts; and

- Irreversible, in that people's lived experiences do not return to baseline conditions once a given process of change is completed.

Accordingly, impacts are qualitatively discussed in relation to criteria. Although not quantified, the criteria against which social impacts are assessed are broadly comparable to the criteria used for assessing biophysical impacts. These include:

- Direction – whether the majority of people affected by an impact will be positively or negatively affected. Values are "P" for positive and "N" for negative;

- Duration – whether the impact will have short, medium or long-term effects on the receptors. Values are "S" for short-term, "M" for medium-term and "L" for long-term;

- Magnitude – whether the extent of the impact can be considered low, medium or high in terms of volume and strength. Values are "L" for low, "M" for medium, "H" for high, "U" for uncertain; and

- Sensitivity (often also referred to as vulnerability) – whether the social receptors have low, medium, high sensitivity. Values are "L" for low, "M" for medium, "H" for high.

The discussion of these criteria will then inform the designation of an impact as of minor, moderate or major significance:

- Minor significance indicates barely noticeable, infrequent, short-term, dispersed impacts that do not undermine sustainable livelihoods or people's quality of life, and that may be balanced out by project benefits;

- Moderate significance indicates quite noticeable, intermittent, medium-term, localised impacts that threaten livelihoods and quality of life and require active management; and

- Major significance indicates severe or fatal, frequent, long-term, impacts that pose a high enough threat to livelihoods and quality of life that intensive management, and perhaps physical displacement, is required.

Impacts of minor significance require tracking – meaning, they must be monitored to ensure that they remain low, but do not require sustained management responses. All impacts that are of moderate and high significance require active management by the Project.

Note that for this assessment, community health, cultural heritage, land use and ecosystem service are analysed separately from other socio-economic impacts.

8 IMPACT ASSESSMENT

This section describes the potential impacts of the Project on receptors prior to, and after, mitigation measures that are part of the proposed development. The assessment follows the methodology outlined in Section **Error! Reference source not found.**.

8.1 Surface Water

8.1.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

8.1.1.1 Construction phase

During the construction phase, areas of the site will be stripped of vegetation and soil, which will leave soils exposed. This may lead to an increase in the amount and velocity of surface runoff, which will change the volume and pattern of surface runoff and reduce infiltration. This may impact surface water bodies by increasing the runoff volume and peak flow rate, whilst decreasing the lag time between the start of rainfall and peak flow. Further, the increased soil erosion can result in a decrease in surface water quality due to an increase in sediment load (turbidity). The increased sediment load can change the sediment transport capacity of perennial streams, causing sedimentation and erosion along the river course and river banks. The potential construction phase impact due to stripping is expected to be of Medium significance.

Surface water can be contaminated due to accidental release of fuel or oil during construction works (including leaks of oil and fuel from construction vehicles and machinery), and also due to inappropriate waste disposal practices. The potential impacts to surface water are expected to have Low significance.

Another source of contamination may be washing and servicing of heavy construction equipment and unmanaged discharge of resulting waste water into the environment and is considered a Low significance impact.

Excavations can trigger slope instability and cause landslides that may result in large volumes of sediment released into surface water bodies. The potential impact is of Medium significance.

8.1.1.2 Operation phase

The mining project will result in some alteration to the drainage landscape. Headwaters of some sub-catchments will be removed, which will change the downstream flow regime although in many cases they are ephemeral and only flow during the wet season (not yet monitored for a full cycle). Medium significance of potential impact is expected due to changes in morphological catchment and flow characteristics.

Surface water collected at the mine site may be contaminated and may impact downstream users or ecosystems if released to the environment. Potential sources of contaminated water include water collected in the open pit, contact water in the process plant area, runoff collected in the TSF in excess of the holding capacity, and runoff from the WRD and stockpiles. Contaminants of concern that could be released from the WRD include arsenic and suspended solids. Contaminants of concern from the TSF are arsenic, cyanide and suspended solids. The release of collected waters to the environment may also impact the drainage channel erosion and sedimentation.

Surface water contamination may also result from erosion and uncontrolled runoff from the WRD and stockpiles. The significance of potential, unmitigated impact is considered to be High.

The mine infrastructure (WRD, TSF, process plant, road embankments, pipelines etc) may block or alter surface flows and runoff. The significance of the potential impact is Medium.

Surface water contamination may also result from inadequate handling and storage or accidental spills of process reagents/chemicals and non-hazardous and hazardous materials from the Project site (mainly process plant and camp). Low significance of potential impacts is expected due to localised contamination.

Road surfaces may generate increased sediment load in the runoff to water courses. Apart from the sediment load, elevated amounts of pollutants including hydrocarbons, rubber, and metal can contaminate the water courses of the receiving environment. The significance of potential impacts is considered to be Medium.

Contamination may result from accidental spills in case of leaky pipelines or pipeline ruptures with potential impacts expected to be of Medium significance.

Impacts on the quality of surface water bodies (Bandama river or tributaries) are expected to be negligible and will not be considered further. The water management plan for the TSF provides for

- Diversion of clean upstream inflows as necessary except during dry conditions when inflow is required to assist supernatant pond returns to meet the full needs of the process plant; and

- Retention of water during wet periods when storage on the TSF will increase and evaporation losses will be augmented by pumping water back over the dry beach.

8.1.1.3 Closure phase

During the closure and post-closure phase, potential impacts may result from the following:

- Release of tailings material and contamination of downstream surface water from failure of the TSF;
- Contamination due to waste rock erosion; and
- Contamination due to failure of mine water management structures to meet acceptable discharge water quality targets.

Significance of potential impacts during the closure and post-closure phase is Medium.

8.1.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

Mitigation for most of the above is catered for in the infrastructure design and/or through the Environmental and Social Management System (ESMS) that includes the Water Management Plan (see **Error! Reference source not found.**). A brief summary is provided below.

8.1.2.1 Site wide water balance and water management

A water balance was produced from available precipitation and evaporation data, preliminary process data and infrastructure configurations, and more specifically, by the design criteria of the tailings storage facility, and completed as part of the DFS.

The water balance model is a dynamic model in that it has been and will continue to be updated as new data become available. Future development will include the incorporation of more automated "switches" to determine, for example, how much of the supernatant water from the TSF pond returns to the treatment plant. This in turn will inform the Mine Water Management Plan during mining operation.

The model covers average wet and dry precipitation conditions. These sequences are derived from the long-term records of Bouaflé precipitation included in Appendix 1 of the ESIA climate Baseline study.

Recycling of the water from the tailings storage facility will be done as much as possible to minimize the use of mine groundwater and the dewatering of the boreholes.

Given the actual dewatering volumes, these residues may be in excess of demand and will have to be returned to the environment. The quality of the water is expected to be good, allowing this to take place without treatment other than sedimenting the suspended solids in relation to the water pumped from the open pit.

There are main inputs and outputs of water from the mine infrastructure and relationships with the surrounding water environment. These elements comprise:

- Open pit;
- Waste dumps;
- Process plant;
- TSF;
- Other hardstanding areas;
- Raw water and potable water ponds; and
- Water and wastewater treatment plants.

The water balance model includes all assumptions about areas, critical deposits and treatment criteria and flow coefficients (the latter reported by the water assessment by the developers of the tailings pond project, Knight Piésold).

Error! Reference source not found. presents site deficits for average conditions (before water withdrawal), as well as required river discharge rates, including the exclusion of excess pit dewatering in the TSF. Peak shortages occur in 2019, mainly due to the predominant mixture of oxide residues during the first months of operation, resulting in poor recovery of the tailings storage facility's supernatant.

Observations from the average conditions modelling are summarised below:

• The supernatant pond volume remains at the minimum operating volume throughout operation until 2024, after which point is greater than the minimum operating volume for 1-2 months during the wet season each year (with the peak wet season volume increasing each year).

• Subsequent to 2024 (prior to which the supernatant pond remains at the minimum operating volume), the peak volume increases from 20,000 m^3 in 2024 to 59,000 m^3 in 2028.

• The facility come to a close operating in September 2033, with 59,000 m^3 within the supernatant pond, and the water balance remains positive after decommissioning (increasing pond volume). The supernatant pond volume in the final 12 months of operation ranges from 10,000 m^3 to 59,000 m^3.

• TSF recycle rates for each year of operation are provided in Table 8-3. The maximum and minimum rates show the range of monthly values throughout each year. The recycle rates are expressed as a percentage of water in the Declaration of the TSF operation termination.

Table 8-1 Average conditions – Plant Site shortfall and river abstraction

Year	Including Pit Dewatering		Excluding Pit Dewatering	
	Process Water Shortfall Volume (m^3/year)	Required River Abstraction Rate (L/s)	Process Water Shortfall Volume (m^3/year)	Required River Abstraction Rate (L/s)
2019*	1,005,000	64	2,669,000	113
2020	**730,000**	**76**	**1,789,000**	**123**
2021	433,000	29	1,560,000	63
2022	178,000	24	1,507,000	62
2023	82,000	5	1,443,000	60
2024	134,000	6	1,392,000	57
2025	290,000	9	1,355,000	55
2026	305,000	11	1,319,000	54
2027	283,000	13	1,284,000	53
2028*	206,000	13	608,000	51

* 2019 operation comprises May-December only; 2028 operation comprises January-June only.

Table 8-2 (by Knight Piésold) summarises the presumed sequence of construction of the TSF following completion of the DFS.

Table 8-2 Staged Embankment Construction

Stage	Tailings Storage (Cumulative) (Mt)	TSF Embankment Elevation*1 (m RL)	Maximum TSF Embankment Height (m)
1*2	6.05	280.8	28.8
2	9.35	285.0	33.1
3	12.65	288.7	36.7
4	15.95	291.9	40.0
5	19.25	294.9	43.9
6	22.55	297.6	45.6
7	25.85	300.2	48.2
8	30.00	303.4	51.4

*1 Includes a minimum freeboard and stormwater capacity for the greater of: (i) 1 in 1,000 year recurrence interval, 72 hour storm event occurring on an average conditions pond, or (ii) 1 in 100 year wet rainfall sequence pond.

*2 Stage 1 embankment designed for 22 month storage capacity.

Table 8-3 Average conditions – TSF recycle rates

Year	Total Recycle Volume (m³/year)	Average Monthly Recycle Rate (%)	Maximum Monthly Recycle Rate (%)	Minimum Monthly Recycle Rate (%)
2019*	682,000	19%	39%	5%
2020	3,320,000	62%	48%	6%
2021	3,549,000	66%	81%	51%
2022	3,602,000	67%	84%	50%
2023	3,666,000	68%	86%	50%
2024	3,718,000	69%	86%	50%
2025	3,754,000	70%	86%	50%
2026	3,790,000	70%	87%	49%
2027	3,825,000	71%	87%	49%
2028*	1,937,000	72%	86%	49%

* 2019 operation comprises May-December only; 2028 operation comprises January-June only.

Process water shortfall is expected to occur under average climatic conditions with no make-up water from river abstraction. Hence abstraction from alternative sources (eg. Bores and/or Bandama River) is required to make up the shortfall under average climatic conditions.

A principal objective is to enable operation of the TSF as a zero discharge facility as far as possible. Hence, the TSF is a key focus of the water balance model. In wet conditions, excess water can build up on the TSF and so recycle to the process plant needs to be the maximum and other water sources may not be required. In dry conditions there may be a deficit in the TSF; if there is insufficient water in the TSF to fulfil all the process needs, then it will need to be augmented with arisings from dewatering.

In practice, TSF and site wide water management at the basin scale, will be handled on a much shorter time-frame so most of the significant surpluses and deficits will be smoothed out. The current water balance model will be refined to allow this (and to determine dewatering arisings contributions to process water as required) once operations has commenced.

8.1.2.2 Surface water modeling, design flow and flood risk

Management of undisturbed runoff

The two largest undisturbed surface water catchments requiring diversion around mine site infrastructure are approximately 60 hectares (Ha) each. The first catchment (CW02a) drains between the waste dump and the Yaouré North Pit and receives rainfall runoff discharge from the second largest disturbed catchment area on the waste dump (DW06 – 63Ha) via a sedimentation basin. The second catchment (CW02) drains to the north east of the CMA Pit and alongside the existing heap leach pads. Due to the steep slope of the upper reaches of both catchments, the time of runoff concentration for the catchments is quite short at only approximately 20 minutes. The peak flow rates estimated for the 100 year return period 20 minute duration event is approximately 26m^3/s for CW02a, which includes the DW06 catchment runoff, and 13m^3/s for CW02.

The lower reaches of the catchments near infrastructure and the pit developments have a much shallower slope. In addition to conveying runoff from a larger upstream catchment than the steeper upstream diversion channels, the shallower slope necessitates larger channel cross sectional areas. Trapezoidal channel designs have been developed for CW02a and CW02 and comprise a 1.2 m depth x 3.0m base width channel and a 1.2m depth x 2.0m base width channel, respectively, with 1(V):2(H) side slopes. The channels combine downstream of the CMA pit development, prior to discharge to the environment, and a channel 1.7m depth x 6.0m base width with 1(V):2(H) side slopes will be required to convey flow downstream of the proposed adjacent haul road and subsequent discharge to the environment.

The remaining undisturbed surface water catchments range in size from less than 1 Ha to 57 Ha, with typically shorter times of concentration due to the smaller catchments. The designed channels are V-shaped for smaller flow rates and trapezoidal for larger flow rates, all with 1(V):2(H) side slopes and depths of 1.2m or less.

All diversion channel designs were based on the Rational Method for estimating peak flow rate, and the following:

- 100 year return period critical duration storm event;
- Manning's n value of 0.029 (gravel lined);
- Channel side slopes of 1(V):2(H);
- Minimum channel slope along the selected diversion alignment.

In the steeper sections of the channel alignments, velocity control measures will be required which can include drop structures, in-channel check dams and meandering channels to reduce the slopes of the channel. Catchpits can also be considered along the channels, which will reduce and delay peak flow rates in the channel in addition to aiding sediment settlement prior to discharge to downstream water courses.

Disturbed Catchment Runoff Management

The disturbed catchment areas consist of the plant site and adjacent infrastructure, the accommodation camp and the waste dump. The largest disturbed catchment areas are the eastern side of the waste dump (DW06 – 63Ha), the infrastructure around the existing heap leach pads (DW07 - 68Ha) and the Process Plant and Rompad Area

(DW08 - 56Ha). Diversion channels along the perimeter of the disturbed catchments were sized on the same basis as the undisturbed catchment diversion channels.

Disturbed catchment runoff pathways were devised based on the estimated footprint of the site infrastructure disturbed catchments in order to allow preliminary sizing of the sedimentation basins required. Preliminary minimum sizing of sedimentation basins for runoff from the disturbed catchment areas on site was based on the 5 year return period peak flow rate.

Particle size analysis was undertaken on two samples collected from rainfall runoff from the Yaouré site. The distribution indicates that the large majority of particles are smaller than 100 microns but larger than 1 micron. Information on the breakdown of particles between these two sizes was not available, however, a target particle size for removal of 50 Micron was selected, as the areal requirements for targeting smaller particles would have resulted in unfeasibly large sedimentation basins. Additional mitigation in the upstream water management such as in-channel check dams and catchpits can be implemented. Sedimentation basins will typically have a minimum settling depth of 0.6m with additional depth required to provide storage capacity for settled materials. The sedimentation basin sizing requirements ranged from 5m x 15m to 42m x 126m (length x width) across the various disturbed catchments.

The channel design details and sedimentation sizing details for all disturbed catchments are provided in the RPS Water Management DFS Report provided in Appendix 6, including estimated earthwork cut volume requirements.

The surface water management plan should be updated in line with any future site infrastructure layout modifications.

Surface Water Management Capital & Operating Costs

The surface water management plan developed does not require any pond and pumping arrangements and as a result there are no capital expenditure costs (CAPEX) associated with pumps, pipelines, etc. and no operating expenditure cost (OPEX) associated with requirements for the strength of pumping.

The only water management related CAPEX/OPEX are those associated with the earthworks required for the construction of diversions and sedimentation basins. The estimated earthworks cut volumes are detailed in the RPS Water Management DFS Report provided in Appendix 6, but can be summarised as follows:

- Diversion drains – total earthwork cut volume 80,000m3;
- Sedimentation basin – total earthworks cut volume has been reduced up to 35,000m3;
- Total earthworks cut volume = approximately 115,000m3.

The proposed earthworks are all possible using standard earth moving machinery which will already be on-site for other construction activities. Applying a project specific earthworks rate to these derived earthworks cut volumes will allow the actual surface water management costs to be estimated.

8.1.2.3 Construction phase

During the construction phase, the following mitigation measures will be implemented:

- Vegetation and top soil will only be stripped prior to the commencement of construction works;
- To prevent contamination of water as a result of washing and/or servicing of heavy construction equipment, workshops with bunded bays and fuelling stations with sufficient bunding and retention structures will be constructed. Impervious surfaces and hydrocarbon traps will be placed in the workshop areas and a fuel station drainage system will be in place for water treatment prior to release to the surface drainage collection system;
- All equipment using hydraulic fluid, oil, fuel or any other substance that has the potential to contaminate surface water if released into the environment will be subject to a preventative maintenance programme;
- Where possible, undisturbed water will be kept separate from sediment laden or otherwise potentially contaminated water;
- Runoff with a large sediment load will be expected from any areas of recently exposed soil or rock. This runoff will be captured and directed via berms or ditches towards specially constructed sediment control structures. Sediment control structures may comprise a series of settlement ponds with additional incorporated filtration measures where required. The number, location and dimensions of settlement ponds, plus requirements for flow attenuation measures will depend on the volume of water requiring treatment, silt load characteristics, topography and access constraints;
- Roads will be inclined either side of centre or all to one side, ensuring runoff drains and minimising water accumulation on the road surface;
- There will be a longitudinal road drainage system for the management of surface water runoff. Road drains will be constructed with appropriate gradient to ensure that sediment does not settle and block the drain;
- Grassed longitudinal road drains with check dams will be constructed when required. Check dams are necessary to reduce erosion and lower the speed of water during storm events;

- Adequate drainage management is required in borrow areas and quarries. Consideration will be given to minimising erosion and runoff from any aggregate or the overburden stock piles. A silt trap will be installed on the down-gradient side of the stockpile and an up-gradient side ditch to divert water runoff from eroding the base of the stockpile and collecting further sediment. Silt loaded runoff will be captured and directed via berms or ditches towards specially constructed sediment control structures. Sediment control structures may comprise a series of settling ponds with additional incorporated filtration measures where required; and

- Emergency procedures will be in place, specifying the steps to be taken in an event of accidental spill of fuel or oil (see Emergency Management Planning, Section 8.11.4 and **Error! Reference source not found.**).

The construction phase impact post-mitigation or enhancement is Low to Negligible.

8.1.2.4 Operation phase

During the operation phase, the following mitigation measures will be implemented:

- Solids settled in the sedimentation pond and drainage channels will be removed during the dry season to maintain sedimentation capacity;

- Erosion protection/control measures and storm water management infrastructure such as perimeter drainage channels and bund walls will be monitored and maintained regularly;

- Undisturbed runoff water will be discharged into an area of vegetation for dispersion or infiltration. Silt traps, gravel, sand bags, and silt fencing will be required at the discharge point in order to prevent erosion and remobilisation of deposited silt. Discharge points will be located a sufficient distance from any watercourses to allow adequate infiltration or settlement of suspended solids prior entering the water course;

- Check dams will be installed at regular intervals within any contact or non-contact water diversions as required. Check dams reduce the velocity of water and therefore allow settlement of coarser sediment particles as well as silt at low flow conditions. Reduction in flow velocity will also prevent scouring of the drainage channel itself;

- Silt traps will be installed where required and where practical for maintenance purposes along drainage channels;

- Hydrocarbon traps will be regularly monitored. Residues from the hydrocarbon traps will be stored and managed according to Perseus's waste management procedure;

- All equipment using hydraulic fluid, oil, fuel, cyanide or any other substance that has the potential to contaminate surface water if released into the environment will be subject to a preventative maintenance programme;

- Procedures laid down in the Emergency Response Plan (**Error! Reference source not found.**) will be followed in the event of a spill;

- Mine water will be pumped from the open pit to settlement ponds where water will be utilised for dust suppression or transferred to the raw water pond for reuse in the plant where supply shortfalls are anticipated. Excess produced water will be discharged to the environment in accordance with water quality standards of Côte d'Ivoire and, where such standards are missing, with IFC effluent water guidance;

- WRD surfaces will be contoured and profiled, to be stable and resistant to long term erosion. Dump development will be regularly monitored to check that construction is as per design;

- The runoff from the WRD will be collected in a drainage system and discharged to environment after passing through sediment traps and where IFC effluent and water quality standards of Côte d'Ivoire are met;

- All waste will be stored in accordance with Perseus's waste management procedures;
- Perimeter storm drains will divert surface water runoff around the process plant and ROM pad. Plant operations will be bunded and collected water pumped back to the plant. Contact water will be settled in attenuation dams and discharged into the environment after its quality meet IFC effluent water and water quality standards of Côte d'Ivoire;

- The quality and volume of any discharge from the tailings management facility will be regularly monitored;

- The tailings/return water pipeline will be stress tested for leaks and weaknesses prior to being placed into operation. Leak detection inspections will be conducted along the entire pipeline on a regular basis; and

- Roads will be maintained regularly. Maintenance will include routine emptying of accumulated sediments from the culverts, check dams and silt traps.

It should be noted that the efficiency of structural mitigation measures is based on their design capacity. When the design capacity is reached or exceeded, their efficiency reduces. The likelihood of an exceedence depends on the design criteria and is currently 1:100 per year.

Mitigation measures reduce impacts to Medium or Low significance levels.

Surface Water Supplies

Current water balance modelling indicates that under foreseeable conditions, external make-up water will be necessary. Nevertheless, the design includes an abstraction from Bandama River to enable water to be taken if necessary.

Process and camp potable water supplies will come from dewatering arisings via appropriate water treatment plant(s). Effluent will be treated in a waste water treatment plant prior to discharge to the environment in accordance with regulations of Côte d'Ivoire and IFC Standards.

Operational mine surface water management, operating essentially as a closed circuit, is not expected to impact on surrounding natural surface water systems.

8.1.2.5 Closure phase

The Project Closure Plan is detailed in the Conceptual Closure Plan (**Error! Reference source not found.**). During the closure phase, the following mitigation measures will be implemented:

- Water in the TSF pond will be drained prior to closure to reduce the potential for overtopping and erosion of the embankments and allow placement of a dry cover. If the supernatant water does not meet discharge standards, it will be treated prior to discharge into the environment;
- The WRD and TSF will be covered with stockpiled soil and vegetated to provide stability against erosion;
- Profiling and contouring will be used to minimise ponding on the tailings management facility surface;
- Diversions and spillway(s) will be in place to minimise potential erosion of the cover from surface water;
- Discharge waters will continue to be treated during the closure period where Côte d'Ivoire and/or IFC standards are not met. Active systems will be transitioned to passive systems following appropriate trial periods.

The mitigation measures outlined will reduce the closure and post closure phase impacts to Medium or Low significance level.

8.1.3 Summary of surface water impacts

See table overleaf.

Table 8-4 Summary of surface water impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO	Surface water, runoff and erosion	Increase of runoff volume, velocity, sedimentation due to the removal of vegetative cover and the exposure of the soils	2	2	4	Medium
CO	Surface water contamination	Surface water contamination due to accidental release of fuel or oil.	1	1	1	Negligible
CO	Surface water contamination	Surface water contamination due to inappropriate waste disposal practices	1	1	1	Negligible
CO	Surface water contamination	Surface water contamination due to washing, servicing of heavy construction equipment.	1	1	1	Negligible
CO	Surface water contamination	Surface water contamination due to hydrocarbon residues from machinery operations	1	2	2	Low
CO	Surface water sedimentation	Sedimentation due to slope instability and consequent land sliding caused by excavations, stock piles.	2	1	2	Low
OP	Surface water flow characteristics	Change in catchment morphological and flow characteristics due to permanent land take, removal of subcatchment headwaters	2	1	2	Low
OP	Surface water contamination	Contamination as a result of pumping from open pit and discharging to environment	2	1	2	Low
OP	Surface water contamination	Contamination due to erosion of waste rock dumps and uncontrolled surface runoff from waste rock dump	2	2	4	Medium
OP	Surface water contamination	Contamination due to seepage of effluent from the Tailings Management Facility	2	1	2	Low
OP	Surface water contamination	Flooding and contamination due to overflow of tailings management facility supernatant pond in times of peak rainfall	2	1	2	Low
OP	Surface water contamination	Contamination of surface water as a result of contact between clean storm water and dirty water in process plant.	2	1	2	Low
OP	Surface water flow alteration	River flow alteration, sedimentation due release of excess water to environment.	2	1	2	Low
OP	Surface water	Contamination due to inadequate handling or storage or accidental	1	1	1	Negligible

	contamination	spillage of chemicals, non hazardous and hazardous materials				
OP	Surface water contamination	Contamination due to hydrocarbon , rubber, metal residues from machinery operations including transport on haul roads	2	1	2	Low
OP	Surface water sediment load	Alteration of sediment loaded runoff, from road surfaces due to increase in traffic.	2	1	2	Low
OP	Surface water contamination	Contamination due to accidental spills from the tailings pipeline and return water pipeline	2	1	2	Low
OP	Surface water flow blockage	Blockage or alteration of surface flow direction as a result of mine development including road embankments, pipeline	2	1	2	Low
CL	Surface water contamination	Contamination and flooding due to Tailings Management Facility failure	2	1	2	Low
CL	Surface water contamination	Contamination due to waste rock erosion	2	1	2	Low
CL	Surface water contamination	Contamination due to failure of mine drainage system	2	1	2	Low

* CO: Construction, OP: Operation, CL: Closure

8.2 Groundwater

This section presents an assessment of the potential impacts of the Project and their significance on the groundwater environment in terms of water quality and quantity in the Project area and downstream of the mine site. Impacts caused during the different mine operating phases are described in sections **Error! Reference source not found.** (before mitigation) and 8.2.5 (after mitigation).

8.2.1 Numerical Groundwater Model

A 3D numerical groundwater flow model has been specifically developed as part of the Yaouré DFS. The groundwater model was used to predict pit dewatering rates, to develop an appropriate pit dewatering strategy and to estimate the potential impact of dewatering on nearby village water supply wells.

The 3D numerical groundwater model was developed using the Groundwater Vistas software with the Modflow-Surfact numerical code. A detailed description of the groundwater modeling approach, model development, model parameters, model calibration and model results is provided in Chapter 6, "Water Management". Appendix 6 of DFS report.

8.2.1.1 Pit Groundwater Inflows

The groundwater model was set up using the seven storm periods, form operation starting in 2018 up to mine closure in 2026. The constraints periods of the model were established according to the key phases of mining operation of new prospects and significant pit extensions. The strom periods are variable duration and summarised in the Table 8 5 and illustrated in Figure 8 1 below.

It is noted that final mining sequence and final pit designs can differ from those modelled for the current assessment. However, the overal entry data must not differ notably from the planned ones.

Two basic dewatering scenarios cases were assessed using groundwater model as follow :

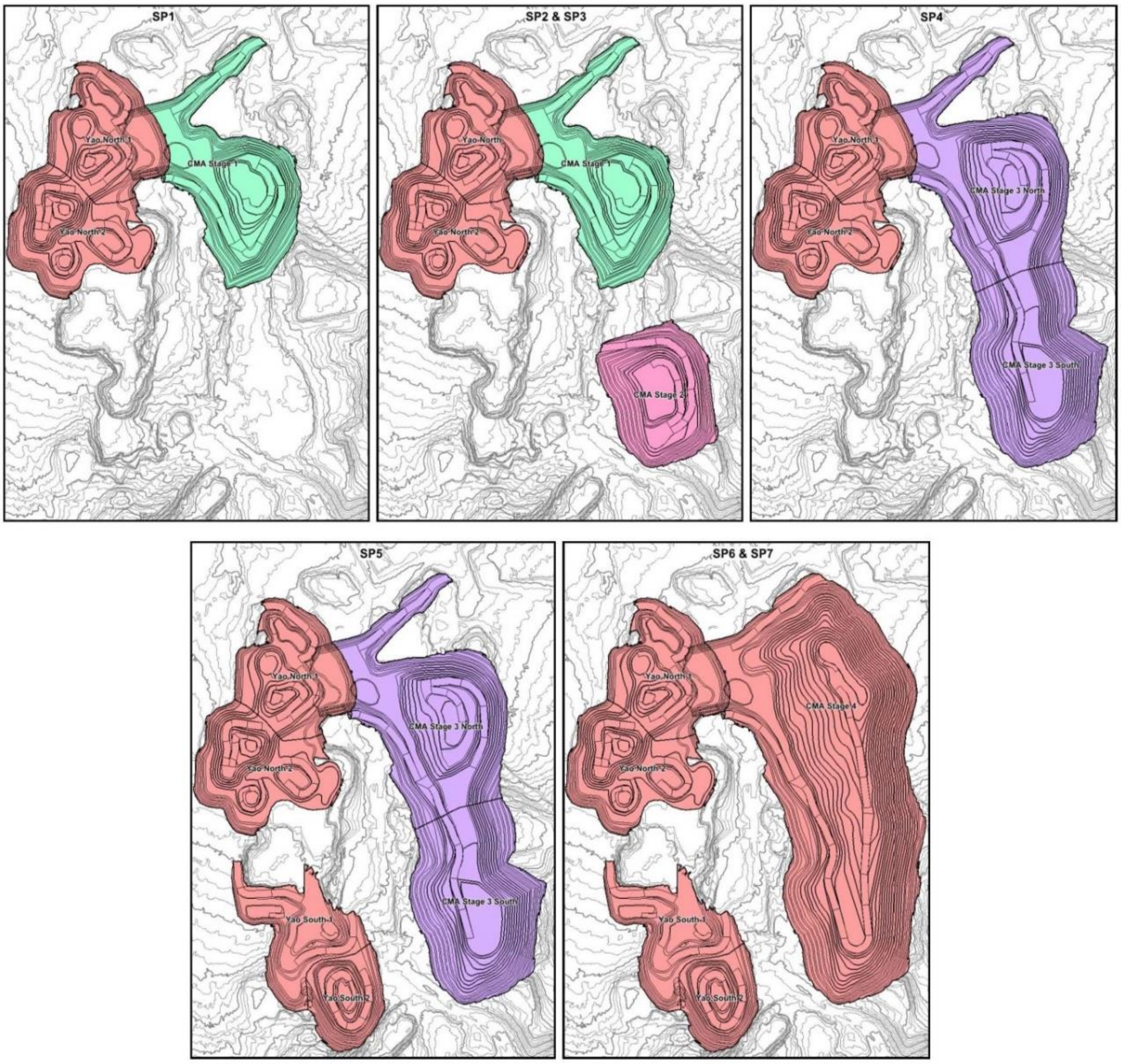
- Pit dewatering using in-pit sumps located at the lowest point of the various pits. In this scenario, the groundwater inflows into the pit were modelled using drainage cells at the pit's basis. There was no ex-pit and advanced pit dewatering using such scenario;

- Pit dewatering using in-pit sumps and dewatering bores along the CMA structure. In this scenario, the drainage cells were installed accoding to the scenario 1, but dewatering bore was included directly at the Eastern side intersecting the CMA structure. The dewatering bore abstraction rate was optimsied for the dewatering of the CMA structure.

Table 8-4 Stress periods of groundwater

Duration (Day)	454	366	91	275	182	365	1,369
Stress period	SP1	SP2	SP3	SP4	SP5	SP6	SP7
Stress period ending date	31/03/19	31/03/20	30/06/20	01/04/21	30/09/21	30/09/22	30/06/26
CMA1	x						
CMA2		x	x				
CMA3				x	x		
CMA4						x	x
North	x	x					
South					x	x	

Figure 8-1 Développement des puits - Périodes de stress



The predicted groundwater inflow rates for the two base case scenarios are presented for the life of mine in Figure 8-1 and Figure 8-2. The charts show the predicted groundwater inflow into each of the individual sub-pits and also a combined total predicted groundwater inflow. It is important to note that these predictions assume on-going dewatering in all various sub-pits across the mine, should pits be mined out and then no longer dewatered then this would lead to reduced groundwater inflows.

Figure 8-1 Pit Groundwater Inflows (In-Pit Sumps Only)

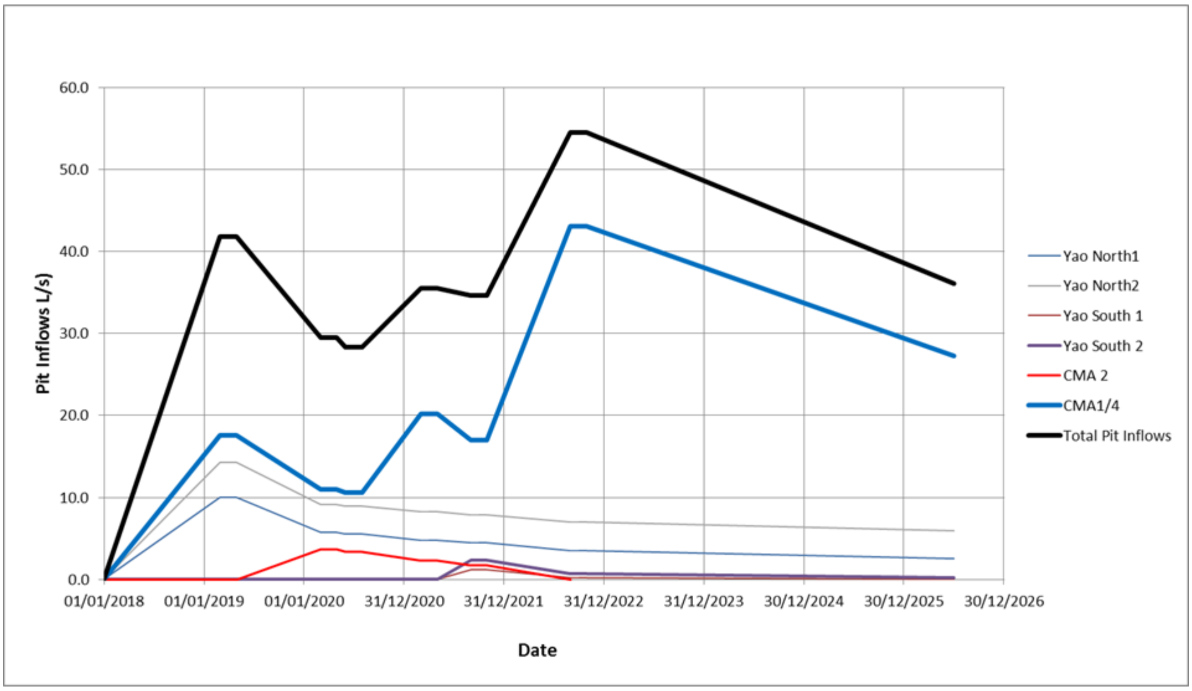


Figure 8-1 shows the predicted groundwater inflows, from in-pit sumps only, to the various pits. The total combined groundwater inflows are predicted to increase up to a maximum of approximately 55L/s over the life of mine. The biggest inflows occur at CMA Stage 4 (up to 43L/s), followed by Yaouré North 2 (up to 14L/s), followed by Yaouré North 1 (up to 10L/s), with relatively minor inflows to the other pits (<5L/s in total).

Figure 8-2 Scenario 2: Pit Groundwater Inflows (In-Pit Sumps) & Dewatering Bore

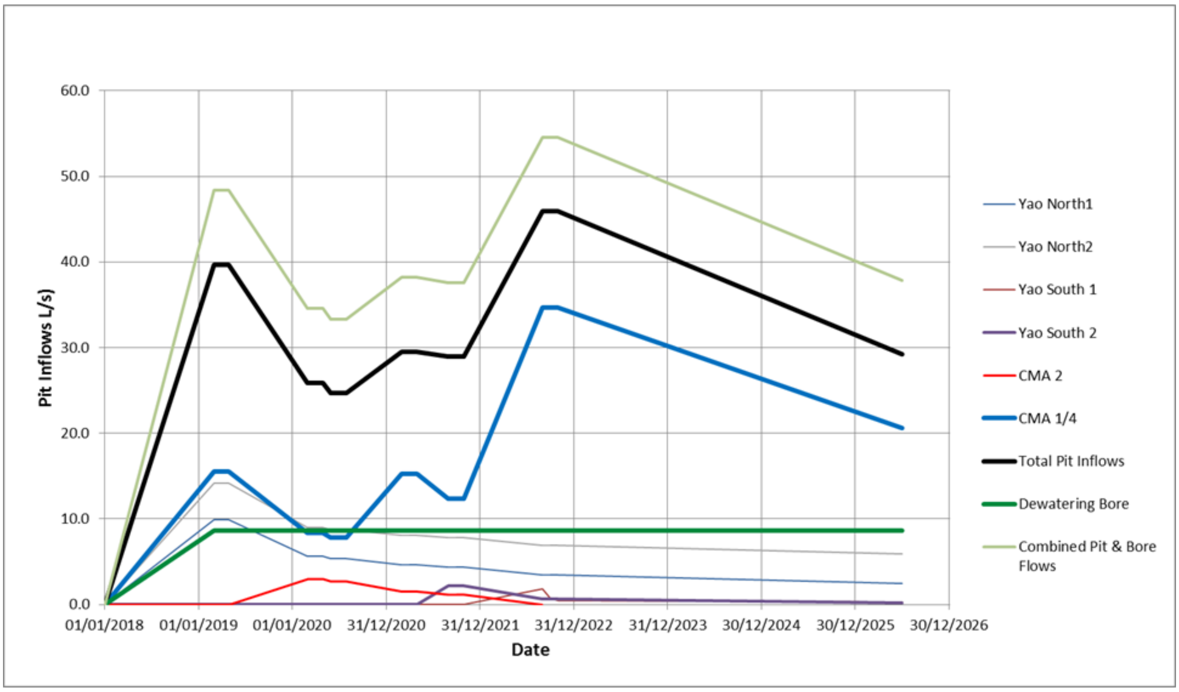


Figure 8-2 shows the predicted groundwater inflows and the dewatering bore abstraction rate for the combined in-pit sumps and dewatering bore scenario. Based on the current model set-up, the model suggests that a rate of 750m3/d (8.6L/s) may be sustainable for a dewatering bore intersecting the CMA (or a similar permeable structure in this area of the pit). The model results show that the total pit groundwater inflows for this scenario are 16% lower (approximately 9L/s less at 46L/s) than in Scenario 1 which does not include a dewatering bore. The total predicted dewatering rate, including both the in-pit sumps and the bore, is approximately the same (55L/s) as in Scenario. Therefore, there is no reduction in the total volume of groundwater dewatering required by targeting the CMA with a dewatering bore. However, there are advantages associated with bore dewatering of the CMA (or a similar more permeable zones); such as providing advanced dewatering opportunities (dropping water levels in advance of mining these levels), enhanced and earlier depressurisation of the saprolite in the eastern hanging wall, pumping less "dirty" water from the pit, and the bore would provide an additional water supply option.

For the modelling exercise the dewatering bore was positioned on the eastern perimeter of the final pit (outside of the pit for the life of mine). However, this location is at least 500m east of the CMA outcrop and therefore with the CMA dip range of 30o-40o the bore would need to be approximately 300m deep to intercept the CMA feature. The modelling completed has provided insight into the effectiveness and impact of installing a dewatering bore, however, there is some uncertainty regarding the feasibility of installing a dewatering bore at this exact location.

The CMA structure could be targeted further west, where it is shallower, earlier in the mine life. A dewatering bore located at the eastern perimeter of the starter pit would effectively dewater the CMA feature and depressurise the shallow weathered sediments early in the mine life, exactly when it is most required. The only constraint would be that as the pit expands the bore would then be within the expanding pit footprint and could be lost. However, at that stage the bore would have largely fulfilled its purpose, intercepting the more significant early mine life inflows from the CMA and assisting with depressurising the clay rich upper sediments which could cause upper pit wall instability. Thus while the modelling completed provides insight into the potential benefits and impact of incorporating dewatering bore(s) into the pit dewatering strategy, the location of dewatering bores will need further consideration of the final mine plan and CMA depth in order to derive an optimal location (in order to minimise depth of drilling, while maximising dewatering effectiveness and longevity). If dewatering bores are to be incorporated into the dewatering strategy then it will also be necessary to undertake further investigations of the CMA in order to confirm its hydrogeological properties (particular to confirm permeability, storage and degree of hydraulic connectivity within the structure itself and the surrounding rocks).

8.2.1.2 Uncertainty of Forecast

The groundwater model parameters were adjusted within the range of probable variability, based on the heterogeneity of hydrogeological parameters, to determine the influence of parameter uncertainty on model predictions.

In summary, predictions of groundwater inputs are most sensitive to changes in fresh rock and CMA permeability, and regional drawdown is most sensitive to changes in fresh rock permeability and transition.

The drawdown of the planned village well is the most sensitive to changes in fresh rock and the permeability of the transition zone.

8.2.2 Dewatering Forecast

Hydrological baseline and groundwater modeling studies are detailed in separate composite documents attached to the ESIA (Hydrological Reference, Preliminary Groundwater Modeling).

On the basis of information available after the completion of the DFS, the preliminary groundwater model indicated annual long-term total inputs of 1,423,000 m^3 (year 4) and up to 2,440,000 m^3 (year 6).

It is possible that extraction wells in a tightly fissured rock aquifer such as the one present may not be able to produce the raw water withdrawal rates required for the treatment plant (337.3 m^3 / hr on overall site) which includes a total average of 7.3 t /

hour of bore water to meet the site's potable water requirements. In addition, the total drying of pit floors during mining will not be possible. Such an assumption should be considered as part of the mine plan.

If dewatering rates are unable to achieve the required drawdown during the available time, alternative strategies could be used such as horizontal side drilling on the pit floors in order to relieve the pressure on the pit floor and assist in the drying and stability of the pit walls.

8.2.3 Source, Receptors, and Significance of Potential Impacts before Mitigation

The following types of potential impact are identified and considered:

- Potential impact on the existing patterns and quantity of groundwater flow at the mine site due to open pit excavation and dewatering, consumptive use, seepage from TSF, WRD and stockpiles, or indirect effects from increased demand from population increase as a result of direct employment and induced development/in-migration; and
- Potential impact on groundwater quality arising from site run-off, discharges, WRD, TSF and stockpiles and unplanned events such as accidental spills.

These potential impacts are further discussed in the following sub-sections.

8.2.3.1 Construction phase

Water supply for construction will mainly come from wells and mine bores until completion of the construction of the tailings storage facility and any water storage facility.

Dewatering will be necessary to make the working environment safe and dry for soil stripping and for excavations. Impact to groundwater levels could be moderate and of Medium significance given the relatively low permeability of strata and proximity of villages to the open pit that may be affected by dewatering.

The clearing of vegetation and soil from infrastructure areas, WRDs, open pit footprint and TSF footprint will potentially locally change the magnitude (increase or decrease) of groundwater recharge. The significance of impacts is considered to be Negligible.

If not properly managed, groundwater contamination could occur through accidental spillage to the soil zone of hazardous or toxic materials either through use (i.e., movement, maintenance, refuelling of site vehicles and plant) or from storage (i.e., oils, fuels, solvents, lixiviants and curing compounds). The potential impacts are anticipated to be localised and of Medium significance.

The greatest number of personnel will be on site during the construction phase and will put pressure on water supply and water disposal (sewage) at the construction camp and employee facilities.

Water supply will be from groundwater sources, following treatment to drinking water standards. Potential (unmitigated) contamination of groundwater could occur through discharge of untreated sewage and the potential impact is considered of Medium significance.

8.2.3.2 Operation phase

As the open pit develops laterally and vertically dewatering boreholes will result in significant drawdown that will decline radially from the open pit (although distortion will occur along preferential flow features such as fracture zones). Forecasts of the Preliminary Underground Flow Model indicate that long-term groundwater pumping rates may be required, although based on available water data and uncertainty of fracture and geometry distribution regolith / bedrock interface outside the mine, it is not at all certain that this rate is necessary or even possible.

Preliminary groundwater model predictions indicate that the extent of drawdown in the bedrock could be tens of metres at the closest village wells (see also Section **Error! Reference source not found.**). If realised this would be a major impact and of high significance. The reduction in groundwater levels could result in reduced groundwater baseflow to watercourses within the extent of drawdown with associated potential impacts to groundwater users. The local significance of potential (unmitigated) impacts due to groundwater drawdown is considered to be high.

The low permeability ground conditions may not be conducive to management of groundwater inflow by advanced dewatering bores external to the open pit. Opportunistic groundwater abstraction from bore holes targeting fracture zones will be undertaken. Groundwater and rainwater inflows to the open pit will be removed by pumping from in-pit sumps. Water will either be returned for use in the processing plant or discharged to environment. Potential exists for contamination of groundwater from seepage of contaminated discharge water. It is anticipated that dewatering water quality will be good apart from high suspended solid content. The significance of potential (unmitigated) groundwater contamination from discharge water is considered Medium.

Water can seep from the bottom of the tailings pond and could impact groundwater levels and quality. An underground drainage system will be installed to collect seepage water and transport it to a collection sump, as well as a cut-off trench and a system for the collection of seepage water downstream.

Groundwater contamination could also occur through accidental spillage to the soil zone of hazardous or toxic materials either through use (i.e., movement, maintenance, refuelling of site vehicles and plant), from storage (i.e., oils, fuels, solvents, lixiviants, cyanide, curing compounds), or from sewerage at the camp area. The significance of the potential impact to groundwater is considered Medium.

Furthermore, leakage from water transfer and tailings pipelines could impact groundwater quality where contaminants are present. The significance of potential impacts is considered Medium.

An increase in population will put increased pressure on water supplies although groundwater is generally the minority supply source. There will additionally be potential impact to groundwater from contamination due to increased untreated sewage. The significance of potential impacts to groundwater from migration of people to the area is considered Low to Medium given the relative abundance of surface water in the region.

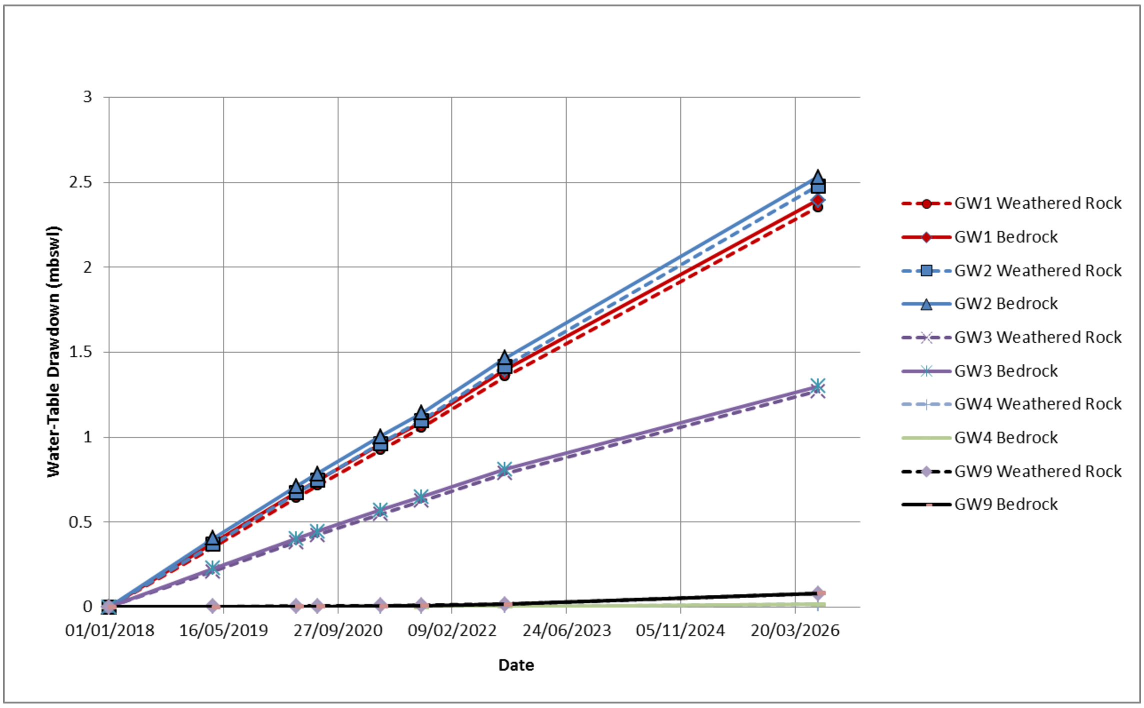
8.2.3.3 Pit dewatering impact on village wells

The model predicted a drop in groundwater level (cone of depression) related to the pit dewatering at the end of the mine life (assuming all pits mined are still being actively dewatered), for Scenario 1 and illustrates that overall there is significantly greater drawdown predicted to the east of the mine in comparison to the west of the mine. As a result there is relatively minor drawdown predicted in the vicinity of the adjacent village of Angovia. The more significant drawdown predicted to the east of the mine is related primarily to the fact that the eastern pit is deepest part of the mine and also the influence of the higher permeability CMA zone in the model which dips to the east. The figure shows an east-west cross-section of the model through the CMA structure and the existing pits for both Scenario 1 and 2 at the maximum pit extent. This illustrates the influence of the CMA in Scenario 1 and the influence of the dewatering bore in Scenario 2.

The 1m drawdown line is predicted to be approximately 1km from the Lake Kossou and 1.2km from the Bandama River, thus no significant impact is predicted as a result of pit dewatering on either Lake Kossou or the Bandama River.

Chart 8.4 presents the predicted drawdown at the various village water supply wells in the towns adjacent to the mine; to the west Angovia (GW1, GW2 & GW3), to the south-west Akakro (GW4) and to the south east Kouakou Gnanou (GW9). The model predicts a water level drawdown at Angovia of up to approximately 2.5 metres below the current water level (mbcwl) in both the weathered rock and the bedrock. There is no notable drawdown predicted in any of the other village wells.

Figure 8-3 Water-table Drawdown at Village Wells



As dewatering occurs from the pit centre via pumping from a sump the deepest point of the cone of depression is further away from the adjacent village wells.

8.2.3.4 Closure phase

The open pit will remain open following the end of mining. Once open pit dewatering ceases then groundwater levels will start to recover and a lake will form. The open pit will become a point of recharge with lateral discharge to groundwater. The significance of the potential impacts is considered Low.

Seepage from the TSF area will continue during mine closure with potential to impact groundwater quantity and quality.

Groundwater contamination could also occur through accidental spillage to the soil zone of hazardous or toxic materials during decommissioning of facilities (i.e., process plant, storage tanks etc) and structures (i.e., transfer pipeline, sewerage systems etc). The significance of the potential impact to groundwater is considered Medium.

8.2.4 Management and Mitigation Measures and Significance of Impacts after Mitigation

Mitigation for most of the above is catered for in the infrastructure design and/or through the Environmental and Social Management System (ESMS) that includes the Mine Water Management Plan (see **Error! Reference source not found.**).

8.2.4.1 Construction phase

Groundwater levels and water quality will be monitored during the construction phase according to the water management plan. Temporary diversion of run-off can be used to supplement watercourse flow where considered necessary. The significance of impact remains Low.

Standard operating procedures (SOP) for handling of hydrocarbons and chemicals are to be followed. Any spills will be contained and remediated as soon as possible and records kept. All fuels and lubricants will be kept in bunded areas/containers. Chemicals will be stored in appropriate containers above ground with suitable secondary containment (sufficient for a 24 hour storm event). The storage facilities will be inspected annually by a qualified person and repairs undertaken where required by appropriately qualified personnel. The significance of the impact after these mitigation measures is Low.

All sewage in the construction camp and mine camp will be collected and treated to Côte d'Ivoire and/or IFC standards prior to discharge. The residual significance of impact is Low.

8.2.4.2 Operation phase

During mine operations the most significant impact to groundwater will be due to a reduction in groundwater levels associated with dewatering of the open pit. Monitoring of open pit inflows and groundwater levels will be conducted to ascertain the extent and rate of drawdown propagation to enable update of the conceptual hydrogeological understanding and groundwater flow modelling to refine predictions. Compensation to watercourses will be achieved through discharge of dewatering water at appropriate locations and diversion of runoff water. Sediment traps will be used to ensure settlement of suspended particulates prior to discharge. Water quality measurements will be made at the point of discharge. The residual significance of impact to groundwater associated with open pit dewatering and water discharge is Low.

Direct impact of groundwater level reduction on village boreholes would be mitigated by compensation water from the dewatering borehole arisings, or possibly by deeper wells further away from the pit. The residual significance of impact to groundwater associated with open pit dewatering and community water supplies is Low.

Groundwater quality monitoring will be conducted around and downstream of the WRD, TSF and stockpiles. Collected seepage will be discharged to the environment following appropriate treated as described in more detail in the Mine Water Management Plan (see **Error! Reference source not found.**). The residual significance is Low.

Groundwater monitoring points downstream of the TSF will be regularly measured for level and quality to ascertain systematic change from baseline conditions and assess potential impacts to receptors. The significance of impact after mitigation remains Low.

Any excess of water discharged from TSF will be treated as necessary to ensure compliance with Côte d'Ivoire and IFC water quality standards. Significance of impact after mitigation is Negligible.

To minimize the infiltration of contaminated water into groundwater, contact surface water will be collected and if necessary treated before discharge or reuse. (e.g., for dust suppression). Oil interceptors will be used and maintained on hardstanding areas. Discharge water quality and downstream groundwater levels and quality will be monitored. The significance of impact after mitigation is Low.

All fuels and lubricants will be kept in bunded areas/containers in accordance with best practice. Chemicals will be stored in appropriate containers above ground with suitable secondary containment (sufficient for a 24 hour storm event). The storage facilities will be inspected annually by a qualified person and repairs undertaken where required by appropriately qualified personnel. All process areas at the plant site have bunds to contain any spillage. Spillages and collected rainfall within the bunded areas are pumped to the process plant for reuse. The significance of impact after mitigation is Low.

The leak detection equipment will be used for the TSF water return line and the plant site will be equipped with a leak response system.

Increased pressure on water supplies in communities associated with an influx of people will be assessed and supervised across the groundwater level and monitoring the quality and level of groundwater. A review of community water supply options will be conducted during the operation phase. With appropriate mitigation/management, the residual significance is Low.

8.2.4.3 Closure phase

The Project Closure Plan is detailed in the Conceptual Closure Plan (**Error! Reference source not found.**). Monitoring of groundwater level and quality will continue during the closure period to identify any impacts and develop a management strategy where required. The residual impact significance remains Low.

Seepage from the TSF will gradually decrease as the tailings consolidate and hydraulic conductivity of materials reduces. Rainfall and run-off recharge to the TSF will be minimised by covering the facility with material. Groundwater quality and level will continue to be measured around and downstream of the TSF during the closure period. The residual impact significance remains Medium.

Discharge waters will continue to be treated during the closure period where Côte d'Ivoire and/or IFC standards are not met. Active systems will be transitioned to passive systems follow appropriate trial periods. With these measures, the residual significance to groundwater from discharge water seepage is consequently considered Negligible.

Appropriate standard operating procedures (SOP) and best practice will be followed during removal and disposal of hazardous or toxic materials storage facilities and decommissioning of structures/facilities. Any spills will be contained and remediated as soon as possible, and records kept. The residual significance to groundwater is considered Low.

8.2.5 Summary of groundwater impacts

See table overleaf.

Table 8-5 Summary of groundwater impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO	Groundwater (abstraction and dewatering)	Reduced groundwater levels and disturbance to groundwater flow direction and decrease in quantity	2	1	2	Low
CO	Groundwater (recharge)	Change (positive or negative) in recharge rates to groundwater where top soil and overburden has been removed	1	1	1	Negligible
CO, OP	Groundwater (quality)	Contamination of groundwater from hazardous or toxic materials accidental spillage or leakage from storage facilities	2	1	2	Low
CO, OP	Groundwater (quality)	Contamination of groundwater from sewage at construction and mine camp	2	1	2	Low
OP	Groundwater (dewatering)	Reduced groundwater levels and disturbance to groundwater flow direction and decrease in quantity; reduced water course baseflow	2	2	3	Medium
OP	Groundwater (quality)	Reduced groundwater quality from WRD and stockpile seepage or discharge from TSF and WRD	2	1	2	Low
OP	Groundwater (quality)	Contamination of groundwater from TSF return water pipeline leakage	2	1	2	Low
OP	Groundwater (quality)	Contamination of groundwater from uncontrolled sewage release associated with influx of people to the region	2	2	4	Medium
OP, CL	Groundwater (quality)	Reduced groundwater quality from TSF seepage	1	1	2	Low
OP, CL	Groundwater (quality)	Reduced groundwater quality from release of collected surface runoff water to surface water systems	1	1	1	Negligible
CL	Groundwater (quality)	Contaminated groundwater from the open pit lake discharging to groundwater	2	1	2	Low
CL	Groundwater (quality)	Contamination of groundwater from accidental spillage to the soil zone of hazardous or toxic materials during decommissioning of facilities and structures	2	1	2	Low

* CO: Construction, OP: Operation, CL: Closure

8.3 Soil impacts

8.3.1 Overview

The area of influence of potential impacts on soil and land capability is mainly expected to be associated with the various infrastructure footprints, although offsite influences might occur down-gradient from the inner exploration licence area if erosion, dust outfall from exposed areas and re-vegetation on exposed soil are not well managed.

The soils' physical and chemical properties and the way in which the soils react to the elements (wind, water erosion, heat, chemical reaction etc.), the sensitivity to having the vegetative cover removed, or their vulnerability to having the topsoil disturbed, and the reaction of the materials to chemical inputs (ease of being taken into solution), are all aspects that were considered in determining sensitivity and ultimately vulnerability of the soils to the proposed development.

Of specific relevance to the soils and potential impacts in the project area is that all soils mapped are to various degrees sensitive to erosion and compaction, with steep terrain increasing the erosion index to moderate or high depending on the relative clay percentage and organic carbon mix.

In addition, the variable depth profiles of the materials mapped are of consequence as the depths of utilisable soil that can be stripped and stored will make for challenging management if all of the utilisable soils are to be harvested (large volumes). These soils are extremely important to the long term sustainability of the project especially for closure and rehabilitation. As a general rule, the amount of soils stripped in the pre-construction phase will be commensurate with the need for soil in the closure/rehabilitation phase. Loss of fertility, texture, nutrient content etc. during storage will be compensated by stripping and stockpiling additional volumes of high quality soils where technically feasible.

The impact of the proposed development on the soils and the resultant change in the land capability will be varied due to the differences associated with the soil forming processes and the resultant variation in the soil physical and chemical composition.

The moderately complex nature of the geology (structurally deformed and folded lithologies, with a moderately steep inclination) and geomorphology of the area, its sub-tropical to tropical climate, all play a significant role in the soil forming process, and have a bearing on the sensitivity and/or vulnerability of the materials when being worked or disturbed.

These factors are important not only in planning the construction and operational activities, but will determine the success of the rehabilitation planning for the future.

The variation in soil structure, texture and clay content of the soils combined with the presence of a prominent ferricrete (evaporite) layer at the base of many of the soil profile ("C" Horizon), all make for complex natural conditions that are going to be extremely difficult to replicate during the rehabilitation stage and at closure.

The potential and probable loss of soil water and the "perched" aquifer that is believed to occur as a result of the ferricrete inhibiting (barrier) layer will need to be assessed and understood as a function of the ecological balance.

The moderately good concentrations of organic carbon but relatively low nutrient stores noted for many of the soils in the soil baseline (see Section 6.4) will also require that a sound Soil Management Plan is adopted based on the impact assessment.

8.3.2 Loss and degradation of utilisable soil resource during construction

8.3.2.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

The pre-construction phase will require site clearance and grubbing of footprint areas for the development of the TSF, WRDs, pit expansion, access roads and powerline, conveyor belts, supporting infrastructure etc. This will require:

- The stripping and stockpiling of utilisable soil (at least top 200 mm depending on activity and availability, possibly more to make up for any losses in soil quality during the storage period);
- The preparation (levelling and compaction) of lay-down areas, foundations and pad footprint areas, footprint to the open cast areas, all infrastructural footprints, the RoM stockpile, access roads and haulage ways;
- Preparation for the construction of the stormwater management system (water dams, reservoir ponds etc.), and the foundations for the process plant and its associated support infrastructure (workshops, diesel bays, stores etc.);
- The clearing, stripping and stockpiling of soil as a result of the construction of all water supply and electrical power supply servitudes and reticulation systems;
- The use of heavy machinery over unprotected soils;
- The possible contamination of the soils by dirty water, chemicals and hydrocarbons spills (dust and dirty water runoff), batching;
- Exposure of soil and excavations can lead to erosion and loss of soil fertility and de-nitrification of soil as nutrients are washed out of the soil; and

- The creation of dust and loss of materials to wind and water erosion due to the removal of vegetative cover and the exposure of the soils and vehicle movement.

Pre-mitigation impact significance of impacts

The loss of the soil resource will impact the biodiversity and ecosystem services, especially the nutrient cycle of the soil and present land use practice (mainly varying intensity of subsistence and semi-commercial cultivation). These activities are perceived to be of great economic benefit to the local economy and land owners and contribute to the ecosystem services of the area.

Utilisable soil is already reduced due to the artisanal mining and cultivation activities. Loss of utilisable soil may be enhanced as a result of the Project. The Project may therefore lead to cumulative negative impacts on soil resources and the utilisation thereof.

The impacts will be mainly long term and may impact on the wider AoI, especially water resources, if not managed appropriately as the soil in the area has a high sensitivity.

Using the impact classification scheme in Section 7.2, the potential impacts associated with these pre-construction activities, i.e., if not avoided, mitigated and managed are Medium to High.

8.3.2.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

The reduction in the significance of the impact will be achieved by the following mitigation measures:

- Limiting the area of impact to as small a footprint as possible, inclusive of waste management facilities, resource stockpiles, the length and width of servitudes, access and haulage roads and conveyencing systems wherever possible;
- Opting for areas with less sensitive soil groups to construct the facility and associated infrastructure;
- Instilling an awareness programme regarding soil management over the length of the mining operation, specifically focussed on soil sensitivity, storage and management;
- The development and inclusion of soil management as part of the general housekeeping operations, and the independent auditing of this management;

- Concurrent rehabilitation of all affected sites that are not required for the operation

- Rehabilitation of temporary structures and footprint areas used during the feasibility investigation (geotechnical pits, trenching etc.) and the construction phase;

- Effective soil stripping during the dryer months when the soils are less susceptible to erosion;

- Separation of the utilisable soils and ferricrete base materials from each other and from the soft overburden where possible;

- Effective cladding of the berms and soil stockpiles/heaps with vegetation or large rock fragments, and the minimising of the height of storage facilities to 5 m wherever possible;

- Restriction of vehicle movement over unprotected or sensitive areas, as well as areas that fall outside of the infrastructure footprints, as this will reduce compaction;

- Soil amelioration (cultivation) to enhance the oxygenation and growing capability (germination) of natural regeneration and/or seed within the stockpiled soils (maintain the soils viability during storage) and areas of concurrent rehabilitation; and

- Ensuring that all contractors appoint environmental control officers to manage construction phase activities according to the requirements of the Management Plans.

Post-mitigation significance of impacts

The above management procedures should reduce the significance of the impacts to Medium in the medium term and Low in the long term after closure. It will allow for the restoration of soils and land use according to the current land uses excluding the TSF, WRD and open pit during closure/rehabilitation.

8.3.3 Loss of utilisable soil resource due to erosion, compaction, de-nitrification and contamination during the operation phase

8.3.3.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

The activities associated with the operational phase that may lead to impacts on the soil resource include:

- Uncontrolled movement of vehicles outside of the mining footprint, causing compaction and erosion of soil;
- The creation of dust due to the mining activities, conveying of material, fine dust particles on the TSF and movement of vehicles over unpaved roads, all of which can cause dust outfall and loss of soil quality;
- The compaction of the in-situ and stored soils and the potential loss of utilisable materials from the system;
- The contamination of the soils by polluted water run-off from the various mining activities, spillage of hydrocarbons from vehicle and machinery;
- Contamination of soils as a result of the use of dirty water for dust suppression and irrigation of the stockpile vegetation;
- Unmanaged soil stockpiles can reduce the nutrient contents and organic carbon store of the soil;
- Potential contamination of soils by chemical spills of reagents handled on site; and
- An impact on soil structure and the soil water balance.

Pre-mitigation impact significance of impacts

Impacts during the operational phase will be negative on soil, land use and land capability. The significance of the impacts, if unmanaged, will be moderate to high. The impacts will last for the LoM, but most of the impacts will be reversible with closure.

It is inevitable that some of the soils will be lost during the operational phase if they are not well managed and a mitigation plan is not made part of the general environmental management programme.

8.3.3.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

The impacts associated with the operational phase will be reduced to moderate significance through the implementation of the following management measures:

- Restriction of activities to the actual footprint area and avoiding vehicle movement in areas outside of clearly designated operation areas;
- Undertaking concurrent rehabilitation throughout the LoM;
- Regular servicing of all vehicles, regular inspection and maintenance of storage areas and dams to prevent spills of hydrocarbons and polluted water;

- Regular cleaning and maintenance of all haulage ways, conveyencing routes and service ways, drains and storm water control facilities;
- Containment and management of spillage; and
- Soil amelioration (rehabilitated and stockpiled) to enhance the growth capability of the soils and sustain the soils ability to retain oxygen and nutrients, thus sustaining vegetative material during the storage stage.

Post-mitigation significance of impacts

Implementation of the mitigation and management measures will reduce the significance of the impacts on the utilisable soil reserves to Medium or possibly Low.

8.3.4 Net loss of soil volumes and utilisation potential and restoration of disturbed areas during closure

8.3.4.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

It should be noted some of the impacts discussed below will actually be caused during the operations phase, but will be noticeable during closure.

Negative impacts will be associated with the following:

- The loss of the soils original nutrient store and organic carbon by leaching of the soils while in storage;
- Erosion and de-oxygenation of materials while stockpiled;
- Compaction and dust contamination due to vehicle movement while rehabilitating the area;
- Erosion due to lack of slope stabilisation and re-vegetation of disturbed areas;
- Contamination of replaced soils by use of dirty water for plant watering and dust suppression on roadways;
- Contamination of soil due to the removal of contaminated liners, containment structures etc.; and
- Hydrocarbon or chemical spillage, e.g., from vehicles.

Positive impacts during closure will be associated with the following:

- A reduction in areas of disturbance (including areas with existing, pre-Project, infrastructure and operations) and return of soil use and capability potential;
- Restoration of a sustainable nutrient balance due to revegetation of soils; and
- The rehabilitation of compacted materials.

Pre-mitigation impact significance of impacts

The significance of negative impacts will remain Medium to High and negative for all of the activities due to irreversible and long term impacts if there is no active management (rehabilitation and intervention) in the decommissioning phase, and successful closure would not be possible.

8.3.4.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

The impacts described above associated with the operational and closure phase will be reduced to moderate significance through the implementation of the following management measures:

- Erosion control, cladding and vegetation of soil stockpiles;
- Adding organic matter to soil stockpiles such as organic kitchen waste, fruit peels etc.;
- Delineation of no-go areas for vehicles where soil is stockpiled; and
- Regular servicing of all vehicles, regular inspection and maintenance of storage areas and dams to prevent spills of hydrocarbons and polluted water.

Post-mitigation significance of impacts

With interventions and well planned management as described above, there will be a reduction in the rating of significance to Low. With successful closure, soil impacts will be reversed on most areas as infrastructure is removed, areas are ripped and the soils are replaced.

There is a positive impact of the rehabilitation of areas that are currently disturbed as a result of pre-Project mining activities.

8.3.5 Summary of soil impacts

See table overleaf.

Table 8-6 Summary of soil impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO, OP	Loss of soil resource	Loss of utilisable resource (sterilisation and erosion), compaction and contamination or salinisation of soil during the pre-construction and construction phase Uncontrolled movement of vehicles outside of mining footprints, causing compaction and erosion of soil	2	1	2	Low
CO, OP	Degradation of soil resource	Compaction by using heavy machinery over unprotected soils	2	1	2	Low
CO, OP, CL	Degradation of soil resource	Contamination of the soils by dirty water, chemicals and hydrocarbons spills	2	1	2	Low
OP	Loss of nutrients and soil fertility	Exposure of soil and excavations can lead to erosion and loss of soil fertility and de-nitrification of soil as nutrients are washed out of the soil, de-oxygenation of soil materials during storage	2	2	2	Medium
OP	Loss of water retention capacity	Impact on soil structure and the soil water balance	2	2	2	Medium
CL	Restoration of disturbed areas	Restoration of a sustainable nutrient balance due to revegetation of soils. Reduction in areas of disturbance Note: most areas disturbed as a result of the Project construction and operation and areas that have been disturbed as a result of pre-Project mining activities will be rehabilitated.	2	1	2	Overall positive

* CO: Construction, OP: Operation, CL: Closure

8.4 Biodiversity

8.4.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

8.4.1.1 Sources

This section provides a summary of the planned Project mining activities and associated infrastructure locations relevant from a biodiversity impact assessment perspective. These proposed mining activities and infrastructures may impact on the biodiversity features comprised within the Project area.

The detailed potential source of impacts and their associated effects on biodiversity are separated into the three phases of the Project (i.e. construction, operation and closure). The compilation of potential source of impacts is a first screening process to help identify all impacts relevant to each phase of the project.

Construction phase

The construction phase will last approximately 18 months. Different potential source of impacts were identified (Table 8-7).

Table 8-7 Summary of potential source of biodiversity impacts associated with proposed mining activities during the construction phase

Source of impact	Description
Site preparation and vegetation clearance	Vegetation will be cleared on all the footprints where infrastructure is to be constructed, including the Tailings Management Facility, the Waste Rock Dumps, the Process Plant Sites, internal access and service roads, workshops and laydown areas, permanent and temporary accommodation camps, etc.
Construction vehicle movement - internal and access roads	Heavy vehicles and earth moving machinery will be used to transport construction material, for site clearance and earth moving of topsoil and overburden, to excavate foundations and to construct of the various infrastructures. This will also be associated with more vehicles on local roads, emission of noise, dust and gaseous fumes.
Topsoil and overburden removal and stockpiling	Topsoil and overburden in infrastructure footprints will be removed using heavy vehicles and earth moving machinery. In addition to potential impacts associated with the movement of vehicles and the impacts caused by removal of soil it might cause dust and noise. Topsoil and overburden stockpiles will be created.
Bulk earthworks, including compaction and levelling	Areas where for example workshops, the Process Plant, ore stockpiles, roads are to be constructed will be compacted.

Chemical, hydrocarbon and other materials storage	Chemicals and potentially hazardous material that will be used during the construction phase will be stored, including diesel, paints and solvents, batteries etc. Spillages may cause harm to the environment. Diesel will be used for vehicles and stand-by electricity generation. A diesel storage area will be prepared. Spillages especially during refuelling can impact on soil and run-off into ground or surface water.
Stream diversions, crossings	Crossing drainage lines may cause siltation of the drainage lines. Crossing through drainage lines may negatively impact on the aquatic biodiversity. Stream diversions will have to be put in place to ensure that clean water is diverted around mine infrastructure.
Plant, conveyor workshop and office construction	Infrastructure construction, including initial storage of construction material, creation of laydown areas, movement of people, etc.
Construction waste	Various waste streams will be generated throughout the construction phase that may impact on the environment, including hydro-carbons, rubble, general waste, potential containers which contained hazardous material.
Construction phase accommodation	A construction camp for construction workers will be operated. This will involve accommodation for approximately 200 people (a total of up to 900 people will be employed on site during construction), provision of water and sanitation, kitchen, potential clinic, generation of waste.
Cement batching and use	Cement will have to be prepared and used in the construction of mine infrastructure. Potential spills from the batching areas can impact on the water resources.
Waste water treatment works	Sewage will have to be treated on site. Spillages into surface- or groundwater can impact on humans or water health.
Borrow pits/quarries	Borrow pits can scar the environment, but can also lead to the creation of dust.
TSF and slurry pipelines construction	Large areas will have to be cleared for the TSF. This area will be compacted prior to TSF construction. The slurry pipeline route will also have to be cleared.
Linear infrastructure construction	Internal roads will be required. This will require clearance of vegetation, stripping of topsoil, creating a base layer, compaction of road areas. Other than these activities, it can lead to increase in vehicle movement, dust, noise, run-off and erosion.
Blasting	Limited blasting might have to be done to establish foundations and as part of the earthworks during construction.
Potential influx of workers	Construction workers will be housed in the construction camp, but may impact on local communities. In addition, people looking for work may also settle in the area, leading to pressure on natural resources and community infrastructure.

During this initial development period, the removal of vegetation can lead to detrimental changes to existing habitats, and an increase in disturbances related to project activities is expected.

Operation phase

Table 8-8 provides a summary of the sources of impacts associated with the operation phase, the longest phase, extending over 6 years.

Table 8-8 Summary of potential source of biodiversity impacts associated with proposed mining activities during the operation phase

Source of impact	Description
Site and operational security	Certain areas will have to be fenced to ensure the protection of domestic animals/cattle and local people.
Blasting, drilling, mining	Blasting in the open pit will be undertaken potentially on a daily basis. The access road between Angovia and Kouakougnanou will be closed during blasting. Noise, dust, airblast that cause vibrations and flyrock may result from the blasting.
Mine waste disposal operations	Waste rock will be dumped with trucks on the waste rock dumps. This can cause dust. The waste rock may potentially lead to acid rock drainage that can potentially impact on ground and surface water quality (unlikely, but should be considered for the sake of completeness)
Pit dewatering	The open pit will have to be dewatered. The water will be reused in the process. Spillage of this water into the environment may impact negatively on water quality as the water may contain nitrates (from blasting), metals and cyanide, and may be acidic.
Non-extractive waste management and disposal	Various non-extractive waste streams will be generated. The wastes will have to be stored in a waste management area if they cannot be returned to the suppliers.
Diesel/hydrocarbon storage and refueling	Spillages may impact on soil or run-off from spillages may impact on water quality.
Materials handling and storage (including cyanide)	Cyanide and potential other hazardous material will be stored in specially prepared storage areas. Spillages may impact on water quality.
RoM ore storage	Run-of-mine (RoM) ore will be stored close to the plant. Run-off can increase silt loads. RoM ore will be transported through a conveyor system. The system creates some noise and spillages of ore from the conveyor may occur.
Plant and associated activities e.g., crushing, milling, leaching	The plant will be associated with process water of which some will contain cyanide, metals and acidity. Spillage would be damaging to water bodies and soil. Milling and crushing activities create noise.
Storm water and flood management	This is a high rainfall area with stormwater management infrastructure to be put in place to manage rainfall and separate clean and dirty water. However, if dirty water spills occur it will harm the environment.
Worker accommodation operational phase	A permanent housing camp will be constructed for the permanent workforce who doesn't come from the communities, such as senior management (however, most workers will find housing in the surrounding communities).
Operational employment	All services including water, sanitation and sewage/waste management will have to be supplied.

Road use	During the operational phase there will be permanent use of vehicles on the internal and service roads. Vehicle use on the major roads will also increase either for the purpose of bringing supplies in or for travelling in general. This may generate noise and dust.
Operation of a small magazine	A small magazine will be operated on site to store limited amounts of explosives.
Workshops and stores	Workshops will be required to service and park vehicles and machinery. There are always hydrocarbons, chemicals and some forms of waste associated with workshops. If spilled, they may harm water bodies and soil.
Sewage treatment	Change rooms and toilets will have to be supplied at the working various areas. This will require provision of water and operation of sanitation services. Sewage wastes will have to be managed. Untreated discharge may lead to high loading of water bodies with nitrogen compounds.
Emergency power generators	Generators require diesel (see diesel storage), but also create noise and emissions.
Process water ponds operation	Process water ponds including the large TSF area will contain hazardous chemicals including cyanide.

Once the project is operational, sources of impacts associated with this phase may include noise, dust, clearance of land, potential pollution.

Closure Phase

The potential sources of impacts associated with the closure phase, which will extend over approximately 3 years, are presented in Table 8-9.

Table 8-9 Summary of potential source of biodiversity impacts associated with proposed mining activities during the closure phase

Source of impact	**Description**
Removal of infrastructure	Unwanted infrastructure will be removed. Rubble and potentially hazardous waste will be created. Noise and movement of people in general may lead to increased nuisance.
Retain stormwater management infrastructure post-closure	Stormwater management infrastructure will be retained until rehabilitation is completed successfully. However, if dirty water spills occur it will harm the environment.
Ripping/loosening of soils	Areas where infrastructure has been removed will be ripped to loosen the soil over large areas. Soil will be placed in some areas as needed. This may increase silt loads in surface water bodies.
Grading, levelling of the landscape	Topsoil will be applied to disturbed areas and waste facilities that have been graded to blend into the landscape. Areas will be revegetated.
Retain infrastructure for communities	Infrastructure that can be retained to the benefit of communities will be retained, including housing, water storage ponds, some roads etc. This infrastructure (e.g., sewage treatment) will have to be operated and maintained to avoid impacts on water and soil.

The closure phase will involve further disturbance as the project winds down and rehabilitation works of the land become necessary, these are associated mainly with the use of heavy machinery and static machinery, source of noise, vibration, pollution. Removal of project associated infrastructures will also increase waste products.

8.4.1.2 Identification of Impacts

A list of impacts was compiled based on the potential sources of impacts as detailed in Section 8.4.1.1. This list was finalised during a workshop held in Abidjan in May 2015 by biodiversity specialists that undertook baseline surveys. Overall eight impacts relevant to biodiversity were identified, see Table 8-10. All impacts are expected to occur throughout the three phases of the Project life, except for habitat loss which is restricted to the construction and operation phases.

Table 8-10 Summary of potential impacts on biodiversity within the Project area

Impact	Project phase	Details of potential impact
Habitat loss	Construction and Operation	Direct habitat loss as a result of vegetation clearance will happen mainly during the construction phase, but continue into the operation phase until the final extent of the pit, TSF and WRD are reached. It is not expected that during the closure phase additional habitat loss will occur. This impact may lead to the mortality of fauna during land clearance, especially for species with small home ranges.
Habitat fragmentation	Construction, Operation and Closure	The clearance of vegetation, as well as infrastructure and road constructions will cause habitat fragmentation. This impact is expected to last until mine closure, and if proper rehabilitation strategies are followed, may be reversible after the life of the mine. Habitat fragmentation will create a potential barrier that may interfere with wildlife movement between different habitat patches. Increased isolation can then lead to a potential deleterious genetic effect. The reduction in connectivity and effective habitat area can increase the risk of localised species extinction due to stochastic effects (the effects of chance events) on populations.
Vehicle collision leading to injury or mortality	Construction, Operation and Closure	Direct mortality (roadkill) or injuries to wildlife can result from collision with Project vehicles due to an increase in road traffic during the three phases of the Project.
Hydrological impacts and siltation	Construction, Operation and Closure	Hydrological impacts include diversion of small streams or discharge of water into the environment that may affect or change water flow of surrounding surface water. This may lead to changes in freshwater ecology, and potential decline in

Impact	Project phase	Details of potential impact
		populations of species reliant on freshwater habitats. The change in water availability can also mean a reduction or loss of dry season drinking sources for terrestrial species. Another potential hydrological impact is related to an increase in sediment load due to erosion that would adversely affect sensitive species and freshwater habitats (e.g., degradation of fish spawning sites). Hydrological impacts are expected to be more severe during the construction and operation phases, but can continue into the closure and post-closure phase, for example an increase in silt loads can be a consequence of loosening soils after removal of infrastructures.
Water and soil pollution	Construction, Operation and Closure	The risk of water and soil pollution is higher during the construction and operation phases, but can also happen during closure if chemicals and other waste products are not disposed of properly. Potential impacts on water and soil quality may arise from site run-off, site discharges (although expected to be infrequent and compliant with legal standards), acid rock drainage and unplanned events such as accidental spills of process reagents/chemicals and non-hazardous and hazardous materials from the Project site.
Habitat degradation	Construction, Operation and Closure	Habitat degradation can come from various sources such as noise, vibrations, air pollutants and dust, and general human disturbance. Habitat degradation is expected for all three phases of the Project. Noise and vibration can adversely affect fauna species, by leading to an avoidance of noisy areas or leading to a change in behaviour (e.g. change in vocalisation frequency). Air pollutants and dust can cause respiratory problems for a range of taxa, and result in mortality or reduced viability in certain physiologically sensitive species (e.g. gill-breathing animals such as fish, and skin-breathing animals such as amphibians). Sensitive habitats may be affected by acidification from high air pollution levels (e.g. freshwater), if pollutants are absorbed into the environment locally. Acid deposition can cause harmful ecological effects to freshwater system when the pH falls below 6, and especially below 5. General human disturbance and daily blasting activities may incur stress for certain taxa which can lead to a reduced reproductive success.
Induced human access and in-migration	Construction, Operation and Closure	An increase in the influx of people coming to the area looking for work, project staff and families, and service providers is expected during the construction

Impact	Project phase	Details of potential impact
		and operation phases. This will increase the pressure on local resources such as fuel (e.g. firewood) and food (e.g. bushmeat) for direct consumption or for commercialisation, and it can result in habitat loss from conversion of natural areas to cultivated land. The improvement of roads and creation of new roads can facilitate human access to the area. It can also facilitate the exportation of goods (e.g. bushmeat and agricultural products). Induced human access will last for the three phases of the Project. Increased monetary supply from staff salaries and in-migration can cause local inflation and contribute to increased commercialisation of local resources.
Invasive species and pathogens	Construction, Operation and Closure	The potential introduction of invasive alien species and increase potential for disease transmission is expected during the three phases of the Project. Invasive species may be introduced in the environment through movement of Project vehicles. Invasive species can out-compete native species and lead to changes in species composition and degradation of habitat. Introduction of predator species may cause declines in native fauna species. Changes in ecosystem composition and habitat structure may lead to a change in disease transmission process and/or increase the likelihood of pathogen transmission to wildlife populations. There also exist a potential for disease transmission between Project staff and local fauna.

8.4.1.3 Receptors

The biodiversity groups targeted by baseline surveys are presented in Section **6.6**. They included six groups: Birds, Reptiles and Amphibians, Flora, Freshwater Species, Large Mammals, and Small Mammals. These groups, and particularly sensitive species, may differ in their response to impacts associated with Project activities (see **Error! Not a valid bookmark self-reference.**).

Factors influencing variations in sensitivity to impacts include species adaptability to change, their population size, the type and intensity of the impact, and current levels of disturbance.

Given the high level of habitat disturbance in the area resulting from historical and current artisanal and commercial mining activities, the Project is not expected to impact significantly local flora and fauna population.

Special attention should be paid to globally threatened species, and species that could trigger Critical Habitat according to criteria 1-3 of the IFC (IFC, 2012). Globally threatened species are species listed either as Critically Endangered (CR EN), Endangered (EN) or Vulnerable (VU) in the IUCN Red List of Threatened Species. They may also include nationally protected species and species not recently assessed by the IUCN Red List but considered threatened according to expert opinion. These species may be particularly vulnerable to potential Project impacts.

Freshwater species have been identified as the most sensitive group, and include the only EN species present in the Project area, *Mormyrus subundulatus*. Although the Project is aiming for zero discharge, potential run-off or polluted water or spillage of chemicals into the Bandama River or Kossou Lake would lead to detrimental changes to the aquatic fauna.

Table 8-11 Potential impact on the different receptors

Impact	Receptor(s) affected	Details of potential impact
Habitat loss	Birds Reptiles and Amphibians Flora Freshwater species Large mammals Small mammals	All biodiversity groups are expected to be impacted by habitat loss. This can lead to either mortality of individuals for species with smaller home ranges or to removal of important habitat for species with larger home ranges.
Habitat fragmentation	Birds Reptiles and Amphibians Flora Large mammals Small mammals	Different birds, amphibians, reptiles, large and small mammal species may vary in their level of sensitivity to fragmentation, edge effects and barrier effects. For example, generalist species may benefit from edge effects, whereas forest specialists may not be able to survive in fragmented areas. Species that are more mobile are generally less susceptible to barrier effects. Therefore we can expect this impact to be less significant on bird and large mammal species. However, some species may be reluctant to cross large cleared areas. Edge effects as a result of habitat fragmentation may lead to a change in the flora species composition.
Vehicle collision leading to injury or mortality	Birds Reptiles and Amphibians Large mammals Small mammals	Terrestrial fauna is susceptible to vehicle collision, and even bird species may be occasional hit by vehicle. However, vehicle movement in the area is already considerable and thus this impact is not expected to be significant.
Hydrological impacts	Reptiles and Amphibians Flora Freshwater species Large mammals	Potential erosion and diversion of streams could have more significant impacts on freshwater species. However, other species dependent on water, for example many large mammal species in the dry season, may also be affected.
Water and soil pollution	Birds Reptiles and Amphibians Flora Freshwater species	All biodiversity groups surveyed may be impacted by water and soil pollution. Certain groups, such as the amphibians, are highly susceptible to environmental pollutants which they can absorb through their skin. Freshwater species are also particularly vulnerable to

Impact	Receptor(s) affected	Details of potential impact
	Large mammals Small mammals	pollution of their environment. Water pollution could also lead to a change in the trophic food chain.
Habitat degradation	Birds Reptiles and Amphibians Freshwater species Large mammals Small mammals	Some species may be more sensitive to noise and general disturbance, such as species that rely heavily on vocalisations. However, given the high level of anthropogenic activities and disturbance in the area, this impact is not likely to increase significantly current threat level.
Induced human access and in-migration	Birds Reptiles and Amphibians Flora Freshwater species Large mammals Small mammals	Most biodiversity groups can suffer from an influx of people coming to the area, which can lead to an increase and acceleration of habitat loss and hunting/fishing. There already exists a high anthropogenic pressure in the Project area. However, influx of people to the area can potentially exacerbate these threats.
Invasive species and pathogens	Birds Reptiles and Amphibians Flora Freshwater species Large mammals Small mammals	Invasive species can negatively impact biodiversity. They can displace the natural vegetation type or change species composition, which can lead to the extirpation of certain vulnerable flora species. Invasive species can also predate on native species and/or outcompete them in their use of food resources. This can also lead to a change in the trophic food chain. Certain species are highly susceptible to diseases that can be transmitted from humans, or alteration to a particular natural disease cycle may increase the risk of disease transmission.

8.4.1.4 Significance of Potential Impacts before Mitigation

A preliminary assessment of impact significance was conducted separately by each specialist and included in their final report, following the significance impact rating presented in Section 7.3. A further assessment was conducted during a workshop held in Abidjan in May 2015, in order to ensure a unified sensitivity and magnitude rating approach across all taxonomic groups. The consensus results of the workshop are presented in Table 8-12. During this workshop, specialists were separated into two teams to discuss in further details and debate the significance of potential impacts on biodiversity.

Table 8-12 Significance rating of potential impacts (i.e., before mitigation)

Impact	Significance rating* (D+E+M)xLxS	Description of rating process
Habitat loss	**Medium** ((4+1+3)x4x2=64)	Habitat loss will be localised and thus will not impact a large area. However, most biodiversity groups will likely be impacted, including some globally threatened species.
Habitat fragmentation	**Medium** ((3+2+3)x3x2=48)	Habitat fragmentation is likely to occur following vegetation clearance throughout the Project. It effects are potentially reversible if proper mitigation measures are implemented given that adjacent vegetated areas have already been subject to significant degradation.
Vehicle collision leading to injury or mortality	**Negligible** ((3+3+2)x1x2=16)	This impact was assessed as negligible. It was judged unlikely that significant mortality or injury would result from this impact given the low wildlife density in the area and the already high traffic.
Hydrological impacts	**High** ((3+3+3)x3x3=81)	The receptor sensitivity is high with respect to the Endangered fish species that was recorded from the area, and the potential wider area of influence that can be impacted.
Water and soil pollution	**High** ((3+3+3)x3x3=81)	Potential discharge of polluted water into the Bandama River or Lake Kossou would lead to detrimental changes to the aquatic fauna, and in particular to the Endangered fish species recorded from the Bandama River. This would also impact a wider area of influence.
Habitat degradation	**Medium** ((3+2+3)x3x4=48)	It is likely that certain species will be impacted by noise, vibration and general human disturbance. However, this impact is not expected to extent to a wide area and background threat levels are already high.
Induced human access and in-migration	**High** ((4+3+3)x4x2=80)	There is a high likelihood that an influx of people will come to the Project area, with their associated impacts probably occurring over the long-term.
Invasive species and pathogens	**Negligible** ((3+2+2)x1x2=14)	If proper mitigation measures are implemented, it is not expected that this impact would pose a significant threat. Certain weed species have already been introduced and not much natural vegetation remains within the Project area.

* Significance impact rating, see Section 7.3: (Duration + Extent + Magnitude) x Likelihood x Sensitivity

8.4.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

8.4.2.1 Management and mitigation measures

This sub-section describes management and mitigation measures that will be implemented by Perseus to minimise identified potential impacts on biodiversity (Table 8-13). Where relevant, the mitigation measures are described by project phase (i.e. construction, operation, and closure), however given that most impacts may potential occur over the entire Project life, general mitigation measures are usually presented.

Table 8-13 Proposed mitigation measures to minimise biodiversity impacts

Impact	Mitigation measures
Habitat loss	<u>Construction and operation</u> • The extent of vegetation clearance should be monitored not to exceed proposed area's surface to be cleared; • Vegetation that is removed should not be burnt but shredded and left on the ground in suitable areas to decompose (preferably in soil stockpiles areas); • Physically removing or scaring away animals immediately before clearance commences. <u>Closure</u> • Re-vegetation of bare areas using native plant species and ensuring that a mix of similar habitats as was there previously is restored if possible.
Habitat fragmentation	<u>Construction and operation</u> • Restore surrounding habitats to cleared areas to compensate habitat loss; • Recreate connectivity between habitat patches in the vicinity to cleared areas where possible. <u>Closure</u> • Recreate vegetation corridor where possible.
Vehicle collision leading to injury or mortality	• Provide driver awareness and training; • Enforce speed limits; • Report any collision, and document species affected and area of occurrence.
Hydrological impacts	• Avoidance of stream diversion where possible; • Stabilise or re-vegetate slopes to prevent erosion; • Monitor freshwater habitat quality.
Water and soil pollution	<u>Construction and operation</u> • Specific measures such as bunded above-ground fuel and chemical storage will be implemented to prevent the pollution that could arise from cement slurry, spillage of fuels and lubricants or other contamination; • Treat contaminated water to attain legal limits before any discharge into the environment; • Oil and fuel spillage kits will be made available in the event of leaks (from machinery or fuel tank); • Digs will be constructed around oil and fuel areas to prevent spillages; • Manage waste and recycle. <u>Closure</u> • Dispose of waste as such that there is no contamination into the environment.
Habitat degradation	• Adoption of the noise mitigation strategy set out in the noise section; • Noisy construction work should be carried out during daylight hours to limit noise levels in the quieter night-time noise environment; • Regular maintenance of equipment and vehicles in accordance with manufacturers specifications to prevent increases in noise emissions;

Impact	Mitigation measures
	• Damping down or covering stockpiles of friable material in dry and windy conditions, use of water sprays to control dust on roads and working areas, covering of dusty materials; • Use directional lighting, light shielding and hoods to mitigate light spill, and use motion sensors and timers to control lighting in areas that do not need to be permanently illuminated.
Induced human access and in-migration	• Local environmental problematic sensitisation; • Develop Project staff conduct guidelines that would include a no hunting policy; • Prohibition of transportation of live or dead animals, plants or seeds in Project related vehicles; • Install gates and inspect vehicle for illegal wildlife products; • Develop alternative money generating activities.
Invasive species and pathogens	• Prohibition of transportation of live or dead animals, plants or seeds in Project related vehicles; • Install gates and inspect vehicle for illegal fauna and flora products; • Provide Project staff with a hygiene and vaccination campaign; • Train staff to recognise key invasive species.

According to IFC GN29, biodiversity offsets are only to be undertaken if significant residual impacts remain after all prior steps in the mitigation hierarchy have been fully assessed and implemented.

8.4.2.2 Significance of impacts after mitigation

If the mitigation measures described in Section 8.4.2.1 are properly implemented, then residual impacts are expected to be at the most of medium significance (see Table 8-14). Ongoing monitoring will be required to ensure that mitigation measures are sufficient. Particularly important will be the monitoring of water quality, as this has been highlighted as the most important resource for the local community, and the freshwater ecosystem is the most sensitive to potential water pollution, contamination and/or flow change.

Table 8-14 Significance rating of potential impacts after mitigation

Impact	Significance rating* (D+E+M)xLxS	Explanation
Habitat loss	**Medium** ((4+1+3)x4x2=64)	There is a definite probability that this impact will occur, even if mitigation measures are implemented.
Habitat fragmentation	**Medium** ((3+2+3)x3x2=48)	Habitat fragmentation is still likely to occur even if mitigation measures are followed.
Vehicle collision leading to injury or mortality	**Negligible** ((3+3+2)x1x2=16)	This impact will remain negligible, as it is the lowest significance rating.
Hydrological impacts	**Medium** ((3+3+3)x2x3=54)	Impacts to the hydrological system are the most important and include a wider area of influence. The significance rating could be reduced to medium if mitigation measures are followed.
Water and soil pollution	**Medium** ((3+3+3)x2x3=54)	Impacts to the hydrological system are the most important and include a wider area of influence. The significance rating could be reduced to medium if mitigation measures are followed.
Habitat degradation	**Low** ((3+2+2)x2x2=28)	This impact could be reduced to low, if mitigation measures are implemented.
Induced human access and in-migration	**Medium** ((3+3+3)x3x2=56)	It is a definite likelihood that an influx of people will come to the Project area. However, a medium significance rating can be obtained if proper mitigation measures are implemented.
Invasive species and pathogens	**Negligible** ((3+2+2)x1x2=14)	This impact will remain negligible, as it is the lowest significance rating.

* Significance impact rating, see Section 7.3: (Duration + Extent + Magnitude) x Likelihood x Sensitivity

8.5 Ecosystem Services Impacts

8.5.1 Summary of Priority Ecosystem Services

8.5.1.1 Overview

The need to 'maintain the benefits arising from ecosystem services' is a recent requirement of the IFC Performance Standards (2012). The concept of 'Ecosystem Services' was made popular by the Millennium Ecosystem Assessment (2005), and is defined as 'the benefits that people, including businesses, derive from ecosystems' (IFC, 2012). These include all the natural products and processes that contribute to human well-being, as well as the personal and social enjoyment people get from nature (WRI, 2011).

Ecosystem services are regrouped into four categories (MA, 2005; IFC, 2012):

- **Provisioning Services** – these are goods or products obtained from ecosystems, such as food, water, timber and other products from plants such as fibre.

- **Regulating Services** – these include benefits obtained from an ecosystem's control of natural processes or by the self-maintenance properties of ecosystems, such as climate regulation, disease control, erosion prevention, water flow regulation, and protection from natural hazards.

- **Cultural Services** – are the non-material benefits derived from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment.

- **Supporting Services** – are the natural processes such as soil formation, nutrient cycling and primary productivity that are necessary for the production of all other ecosystem services.

In line with the IFC Performance Standards, this section identifies and prioritises ecosystem services in the Project area, providing baseline information on how these services are of relevance to local communities, and how likely they are to be impacted by the Project activities.

8.5.1.2 Key Ecosystem Services and Beneficiaries - Baseline

A list of ecosystem services and their beneficiaries was established during a workshop held in Abidjan in May 2015 (Table 8-15). As questions relating to ecosystem services require a multidisciplinary approach, this workshop brought in experts that participated in the biodiversity, social, cultural heritage and land use baseline surveys and assessments.

The information and data sources for the ecosystem service baseline have been collated from other ESIA chapters (e.g. biodiversity, social, soil, water, cultural heritage), and in some cases, specific information regarding Ecosystem Services were collected as part of baseline surveys conducted by the different specialists.

The various ESIA chapters included quantitative and qualitative data collected through field studies conducted mainly between 2014 and 2015. These data provided sufficient information to determine baseline levels for the different ecosystem services. When this information was insufficient, expert judgement has been utilised together with further engagement with the ESIA specialists during the workshop that was held in Abidjan in May 2015 in order to generate an accurate characterisation.

The main output of the ecosystem service baseline has been to produce qualitative information and the assumptions made have been based upon ecosystem service importance as well as their sensitivities. The resulting baseline is, to a certain degree, a dynamic assessment which will change over the development and lifetime of the project and can therefore be refined to advise the project further.

The following ecosystem services, their sub-categories, beneficiaries, and baseline were identified for the Project area.

Table 8-15 Ecosystem services relevant to the Project area

Ecosystem Service Category	Service	Subcategory	Description	Beneficiaries	Baseline
Provisioning	Food	Collecting wild fruits	Edible plant and liana species that are harvested for local consumption or for commercial purposes.	Local communities	Several tree and liana species are harvested throughout the year for their fruits, such as the Néré (*Parkia biglobosa*). During botanical surveys, 13 species were identified as being consumed locally and/or harvested for commercial purposes.
Provisioning	Food	Hunting	Bushmeat that is hunted within the Project area for local consumption and/or for commercial purposes.	Local communities	It was difficult to assess the prevalence of hunting in the area because at the time baseline surveys were conducted, there was a ban on hunting due to the Ebola crisis. However, several gunshots were heard and snares were also seen during biodiversity baseline surveys, which indicate that hunting is practiced in the area. Furthermore, inactive hunters mentioned that before the ban on hunting was implemented, a bushmeat market existed in the village of Angovia, and that local restaurants would serve bushmeat. Apparently there was also a more extended bushmeat network in place, where people would come to the area to buy large bushmeat quantity and resell it in bigger cities (i.e. Yamoussoukro).
Provisioning	Food	Fishing	Wild fish caught for local consumption and/or for commercial purposes.	Local communities	Although fishing is not a primary sector or work, as identified from the socio-economic surveys, it is a significant source of food within the Project area. Fishing activities are conducted both on the Kossou Lake and the Bandama River. There are several professional fishermen living in fishing villages close to the Kossou Lake.

Provisioning	Food	Agriculture	Cultivated plants or agricultural products (including perennial and annual crops) that are harvested as food or to be sold commercially.	Local communities	Agricultural activities (including perennial and annual crops) are practised by the majority of households in the Project area. The main crop cultivated on a commercial scale in this area is cacao. According to socio-economic surveys, agriculture is the primary sector of work (43.7% of the local population are farmers).
Provisioning	Food	Livestock	Animals raised for domestic consumption or to be sold commercially.	Local communities	An estimated 11,500 farm animals live in priority villages within the Project area. These are mainly chicken (59%). Other domestic animals are raised, such as sheep and pigs. Large herds of cattle also use the savanna habitat comprised in the northern part of the Project area.
Provisioning	Fuel	Firewood for cooking	Non-timber tree products that are harvested within the Project area to be used for cooking.	Local communities	For 80% of the households living within the Project area, the main cooking fuel utilised is wood that is harvested locally. Charcoal production is also common in the northern part of the IEL, destined for domestic and economic purposes.
Provisioning	Freshwater	-	Include surface water and rainwater used for drinking, cleaning and industrial processes.	Local communities/ Project	Freshwater, coming from surface water, is an important resource for the local communities, used for drinking, washing, cooking, etc. Access to good quality water is a main challenge in the Project area and was identified as a source of concern during socio-economic household surveys.
Provisioning	Natural medicine	Medicinal plants	Biological materials derived from the ecosystem and used for medicinal purposes.	Local communities	A total of 42 plant species were identified as being used locally in traditional medicine, to treat diseases affecting humans and/or their livestock. Most of these species are evenly spread out throughout the Project area..
Provisioning	Biological	Construction	Non-timber tree products, ,	Local	Many houses and religious structures are built with

	raw materials	materials	soil, and other products harvested from the Project area that are used as construction materials.	communities/ Project	locally available materials (e.g. straw, wood, clay). These are widely available and harvested from the local environment.
Provisioning	Abiotic raw materials	Mineral resources	Mineral resources extracted from the environment used for commercial purposes.	Local communities/ Project	Artisanal gold mining is one of the two main economic sectors for the people living within the Project area. In this area, gold has been exploited commercially since the 80's, and more recently has also attracted illegal large-scale mining activities.
Provisioning	Ornamental resource	Jewellery and ornaments	Products derived from the ecosystem that serve aesthetic purposes.	Local communities	Certain animal and plant parts are used as ornaments or jewellery. For example, fish scales are used to fabricate bracelets in the area.
Regulating	Seed dispersal and pollination	-	Role ecosystems play in transferring pollen from male to female flower parts, or in disseminating seeds (ex. bees and birds).	Local communities	Many animals within the Project area play a role in seed dispersal (most small and large mammal species) or pollination (e.g. bees) of certain flora species, including some agricultural crops.
Regulating	Regulation of natural hazard	Forest cover	Forest cover can provide natural protection from wind,dust and fire.	Local communities/ Project	Forest cover can provide a natural protection from wind and dust. There is already a high dust level along the dirt roads comprised within the Project area, but land clearing will likely lead to an increase in dust in the environment. Forested habitat acts as a natural barrier to the spreading of fire, and thus change in land use can impact on fire intensity and frequency.
Regulating	Erosion control	-	Vegetative cover plays an important role in soil retention and in the prevention of siltation of surface water.	Local communities/ Project	Vegetation cover binds soils and prevents soil loss. This control prevents siltation of surface water. Some parts of the Bandama River contain high sedimentation levels due to the recent clearing of riverine vegetation by illegal miners.

Regulating	Pest control	-	Influence ecosystems have on the prevalence of crop and livestock pests and diseases.	Local communities	Predators from the Project area such as birds, bats, snakes and other animals may control pest and plagues attacking crop and livestock.
Cultural	Spiritual values	Sacred forests	Spiritual or religious values people attach to ecosystems orLandscapes.	Local communities	Several sacred forests can be found within the Project area, covering a combined total area of 110 ha. These are generally located on hilltops where a forested cover remains because these areas are harder to reach.
Cultural	Spiritual values	Cemeteries	Areas to which a spiritual value has been attributed.	Local communities	Several cemeteries can be found within the Project area, covering a combined total area of 110 ha. These areas usually harbour a forested cover and are use for reverence.
Cultural	Educational and cultural heritage values	Archaeological artifacts	Artefacts of ecosystem-derived tool or household items that have been used historically.	Local communities	Artefacts belonging to the Neolithic period were found in the Project area. Through years of artisanal mining activities, these artefacts have been moved around and are scattered throughout the Project area.
Cultural	Ecotourism	-	Recreational pleasure people derive from natural or cultivated ecosystems.	Local communities	A popular area for conducting ecotourism activities is the confluence of the White and Red Bandama Rivers.
Cultural	Recreational values	Hobby/Game	Animal or plant parts used for recreational purposes.	Local communities	Animal and plant parts are sometimes used to fabricate games, such as the seeds of a liana that are used locally as marble.
Supporting	Nutrient cycling processes	-	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	Local communities	Forested habitats are extremely efficient at retaining nutrients (closed-systems) which are stored either in soil, bacteria and other primitive life forms, vegetation (e.g. Leaf, woody materials etc.) and fauna components (e.g. animals and released through dying or dead organic matter and are transported via water and erosion processes).
Supporting	Soil	-	Role ecosystems play in	Local	Soil formation process is dependent on the

	formation processes		sustaining the soil's biological activity, diversity, and productivity.	communities/ Project	ecosystem for such things as, for example, organic matter decomposition, rainfall, and atmospheric gas cycle. Soil can also filter contaminated water and breakdown chemicals. Soil formation is fundamental to the existence of ecological communities. Productive soils contribute to the production of food, fuel and building materials,
Supporting	Photosynthe sis	-	Photosynthesis produces oxygen necessary for most living organisms.	Local communities	The forested areas and algae perform photosynthesis, which produces oxygen necessary for most living organisms.

Table 8-16 Baseline data for key Ecosystem Services relevant to the Project

Ecosystem Service Category	Service provided	Project needs related to Ecosystem Services
Provisional	Freshwater	Mining activities will require water for plant water supply, haul road dust suppression, construction water, potable drinking water, vehicle wash, etc. Technological water will come preferentially from recycle of supernatant water from the TSF, supplemented during dry conditions from arisings from dewatering, either from pit inflows (via suitable settling to remove suspended solids) or from boreholes. Potable water will be supplied preferentially from dewatering boreholes. Abstraction from Kossou Lake will only be activated at times when these sources are insufficient.
Provisioning	Construction materials	Local materials such as wood and soil may be needed during all three phases of the Project.
Provisioning	Mineral resources	The Project is based on the extraction of the mineral resource (i.e. gold) present in the area.
Regulating	Forest cover	Forest cover can provide a natural barrier to reduce dust, noise and fire propagation.
Regulating	Erosion control	The Project relies on vegetation areas to provide natural erosion control measures to protect roads and mine infrastructures.
Supporting	Soil formation processes	The Project is reliant on fertile soil that will be used during closure.

8.5.1.3 Prioritisation of Ecosystem Services

Priority Ecosystems Services are defined as

- Those services on which project operations are most likely to have an impact and, therefore, which result in consequent adverse impacts to Affected Communities; and/or

- Those services on which the Project is directly dependent for its operations (e.g. water).

To identify priority Ecosystem Services, a value was attributed to each Ecosystem Service following Table 8-17 (Rio Tinto, 2012).

Table 8-17 Assessing the value of Ecosystem Services

		Replaceability / Resilience of Service		
		High (many spatial alternatives)	Moderate (some spatial alternatives)	Low (few to no spatial alternatives)
Importance of service to beneficiaries	Low	Low	Low	Medium
	Moderate	Low	Medium	High
	High	Medium	High	Critical
	Essential	High	Critical	Critical

The value rating is mainly based on the assessment of two parameters:

1) Importance of ecosystem services to beneficiaries; and

2) Replaceability of the service.

Importance of ecosystem services to beneficiaries and the Project was assessed according to the following criteria and assigned a rating from low to essential:

- Intensity of use – e.g. daily, weekly, seasonal use of a provisioning service; number of downstream villages reliant on erosion or flood control services;
- Scope of use – e.g. household level vs. village level; subsistence use, trade or both;
- Geographic proximity (where possible); and
- Degree of dependence: e.g. contribution of fish or bushmeat to total protein in the diet.

Replaceability of ecosystem service was assessed according to the following criteria and assigned a rating from low to high:

- The existence of spatial alternatives (other sites where the same ecosystem service is also provided and that are close enough to be utilised by affected communities); and
- The sustainability of spatial alternatives given the potential for increased resource use, including a consideration of other users and the existing status and threats to the resource.

Following assessment of the importance of ecosystem services to beneficiaries and its replaceability, the value rating could then be completed and attributed to each ecosystem service that had been identified. This process was done separately for ecosystem services relevant to local communities (Table 6-37) and for the Project (Table 8-19).

Table 8-18 Summary of priority rating for ecosystem services important to local communities

Service	Subcategory	Importance of service to beneficiaries	Replaceability	Value rating
Provisioning				
Food	Collecting wild fruits	Moderate	Moderate	Medium
Food	Hunting	High	Low	Critical
Food	Fishing	Essential	Low	Critical
Food	Agriculture	Essential	Moderate	Critical
Food	Livestock	Moderate	High	Low
Fuel	Firewood for cooking	Essential	Low	Critical
Freshwater	-	Essential	Moderate	Critical
Natural medicine	Medicinal plants	Essential	High	High
Biological raw materials	Construction materials	High	High	Medium
Abiotic raw materials	Mineral resources	Essential	High	High
Ornamental resource	Jewellery and ornaments	Low	High	Low
Regulating				
Seed dispersal and pollination	-	Essential	High	High
Regulation of natural hazard	Forest cover (wind stopper and dust)	Essential	Low	Critical
Erosion control	-	High	High	Medium
Pest control	-	Essential	High	High
Cultural				
Spiritual values	Sacred forests	Essential	High	High
Spiritual values	Cemetery	Essential	Moderate	Critical
Educational and cultural heritage values	Archaeological finds	Low	Low	Medium
Ecotourism	-	Low	Low	Medium
Recreational values	Hobby/Game	Low	High	Low
Supporting				
Nutrient cycling processes	-	Essential	Low	Critical
Soil formation processes	-	Essential	Low	Critical
Photosynthesis	-	Essential	Low	Critical

Table 8-19 Summary of priority rating for ecosystem services important to the Project

Service	Subcategory	Importance of service to beneficiaries	Replaceability	Value rating
Provisioning				
Freshwater	-	Essential	Moderate	Critical
Biological raw materials	Construction materials	Moderate	High	Low
Abiotic raw materials	Mineral resources	Essential	Moderate	Critical
Regulating				
Regulation of natural hazard	Forest cover (wind stopper and dust)	Moderate	Moderate	Medium
Erosion control	-	Essential	Moderate	Critical
Supporting				
Soil formation processes	-	Essential	Moderate	Critical

A final screening was performed where only value ratings of High and Critical were taken forward into the assessment of impacts. Ecosystem Services of Medium value are still considered relevant to beneficiaries and the Project, and are included in the impact assessment in less detail. Finally, Ecosystem Services of Low value are scoped out of the assessment (i.e. three Ecosystem Services relevant to the local communities and one relevant to the Project).

8.5.2 Potential Impacts on Priority Ecosystem Services before Mitigation

A project following the IFC Performance Standards must identify impacts on priority Ecosystem Services, and apply the mitigation hierarchy to avoid, minimise and reduce impacts on these services (IFC, 2012).

Delineate the geographic scope of the Ecosystem Service impact assessment

A first step before conducting the impact assessment was to determine the area of influence.

Geographical coverage and identification of the area of influence was defined on the basis of the following factors (Rio Tinto, 2012):

- The likely distance at which the proposed mining activities will impact the availability and functionality of ecosystem services;
- The likely distance that people are willing to travel to utilise natural resources on a regular basis; and

- Water catchment areas likely to be affected by the mine.

The areas of influence identified for Ecosystem Services is similar to those considered during biodiversity baseline surveys. Therefore, a different area of influence has been delimitated for terrestrial Ecosystem services and for freshwater Ecosystem services.

It is assumed that most terrestrial Ecosystem Services impacts will occur in the IEL. The furthest distance local people regularly travel to access Ecosystem Services was estimated at approximately 5km.

For freshwater Ecosystem Services, a wider area of influence is considered given the larger indirect impact area of influence, which included the Bandama River Basin and its tributaries.

Potential impacts on priority Ecosystem Services

Over the lifetime of the mine, it is expected that there will be a range of impacts on ecosystem services in the Project area of influence, with implications for the livelihoods, health and culture of communities within this area.

The drivers of ecosystem change either involve direct, indirect or secondary drivers. The most significant direct drivers identified by the World Resources Institute (2011) are as follows:

- Changes in local land use and land cover;
- Harvest and resource consumption;
- Pollution;
- Introduction of invasive species; and
- Climate change.

Significant indirect drivers were identified by the WRI:

- Demographic;
- Economic;
- Sociopolitical; and
- Religious or scientific, technological factors.

In relation to the specific proposed Project activities, the above lists have been focused on the key sources of potential impacts on ecosystem services:

- **Occupation of land during Project construction and operation** – this will result in habitat loss, degradation and fragmentation, reduced access to resources for beneficiaries;
- **Disturbance to habitats and species** – including activities that cause disturbance or habitat degradation as well as potential introduction of invasive species;
- **Potential impacts on surface water** – due to potential pollution from spillage or leak, and/or fluctuation in water flow from abstraction or discharge; and
- **Impacts on availability and quality of resources** – due to demographic and economic changes relating to the influx of people seeking potential employment.

More specifically, specific impacts were identified for each of the four Ecosystem Service categories:

Provisioning service

The most important impact will be related to the loss of habitat during the construction and operation phases. This will reduce the availability in food and fuel resources, such as wild fruits and firewood. It will also decrease the amount of arable land available to the local communities. As a result, people may have to travel further to cultivate and/or find food and fuel resources.

Another potential severe impact is the decrease in water quality due to accidental spillage or leak of contaminants related to Project activities. Local communities rely on freshwater in their daily activities and this impact would be catastrophic for the local communities.

Finally, there are potential indirect impacts from in-migration that may increase pressure on local wildlife population and habitats. Indeed, people coming to the area looking for work may conduct secondary activities, such as agriculture and hunting/fishing. This will put pressure on the availability of freshwater and terrestrial resources.

Regulating service

Activities during the all three phases of the Project will result in clearing of vegetation on certain slopes and slopes catchment, resulting in a moderate reduction in erosion regulation provided by these habitats. Given the high rainfall intensities experienced in most of the project area, the loss of natural regulation services in addition to any erosion directly caused by Project activities can be a significant concern. Ground disturbance during construction and pit excavation may increase the potential for erosion.

The clearance of vegetation will also decrease the surface of tree cover that act as natural barrier against natural hazard.

Cultural service

The main impact on cultural services is the loss of sacred forests and/or cemeteries as a result of land clearance during construction and operation. There might also be change in ambience at these particular locations as a result of noise and light during construction and operation.

Supporting service

Forest and other habitats contribute to soil formation processes with natural vegetation providing a source of organic matter which is broken down and recycled. Soil is critical for agricultural activities and once vegetation is removed, is quickly lost. Mining activities may lead to compaction, blending of top-soil with sub-soils, and de-nitrification leading to infertile soils. Mining dusts may also change the constituents of soil, increasing contaminants as well as changing the texture of soil. Pollutants may also inhibit soil-forming processes. Impacts from run-off also reduce the fertility of soil. However, the most important factor is the removal of vegetation that protects soil and enriches it with additional organic material.

Impact Assessment on priority services

The significance of the impact is assessed according to (i) the value / sensitivity of the receptor and (ii) the magnitude of the impact (Rio Tinto, 2012). The allocation of a value rating to an ecosystem service takes into account the specific criteria detailed under the prioritisation process section 8.5.1.3.

The other parameter to consider is the magnitude of the impact. The term magnitude is used here to encompass various possible dimensions of the predicted impact including:

- The nature of the consequence (how resources and/or receptors are affected);
- The size, scale or intensity of the effect;
- Geographical extent and distribution;
- Temporal extent (duration, frequency, reversibility); and

- Where relevant, the probability of the impact occurring as a result of non-routine events.

Magnitude is then ranked between Negligible and Major (see definitions in Table 8-20).

The results of the impact assessment for Ecosystem Services are presented in Table 8-21.

Table 8-20 Evaluating significance of impacts on Ecosystem Services

Value of Receptor		Magnitude of Impact			
		Negligible	**Minor**	**Moderate**	**Major**
		Impacts are within the normal range of variation.	Impacts results in a small reduction in the availability or functionality of ecosystem service and/or has implications for a small number of people relative to the population within the area of influence.	The impact results in a moderate reduction in the availability or functionality of the ecosystem service and/or has implications for a substantial number of people relative to the population within the area of influence. Does not threaten the long-term viability of the service.	The impact results in the loss of all or significant proportion of the availability or functionality of an ecosystem service and/or has implications for the majority of people within the area of influence. The long-term viability of the service is threatened.
Negligible	Ecosystem service is of negligible importance to beneficiaries.	**Not significant**	**Not significant**	**Not significant**	**Not significant**
Low	Ecosystem service is of low importance to beneficiaries (local, regional and global) or is of moderate importance, but with many spatial alternatives available.	**Not significant**	**Not significant**	**Minor**	**Moderate**
Medium	Ecosystem service has moderate importance to beneficiaries and moderate replaceability (some spatial alternatives), high importance to beneficiaries and many spatial alternatives, or low importance and few to no spatial alternatives.	**Not significant**	**Minor**	**Moderate**	**Major**

Value of Receptor		Magnitude of Impact			
		Negligible	**Minor**	**Moderate**	**Major**
		Impacts are within the normal range of variation.	Impacts results in a small reduction in the availability or functionality of ecosystem service and/or has implications for a small number of people relative to the population within the area of influence.	The impact results in a moderate reduction in the availability or functionality of the ecosystem service and/or has implications for a substantial number of people relative to the population within the area of influence. Does not threaten the long-term viability of the service.	The impact results in the loss of all or significant proportion of the availability or functionality of an ecosystem service and/or has implications for the majority of people within the area of influence. The long-term viability of the service is threatened.
High	Ecosystem service is of high importance to beneficiaries and has moderate replaceability (some spatial alternatives); is of moderate importance to beneficiaries and has few or no spatial alternatives; or is essential to beneficiaries but has many spatial alternatives.	**Not significant**	**Moderate**	**Major**	**Critical**
Critical	Ecosystem service is of high importance to beneficiaries and has few to no spatial alternatives; or the service is of high to essential importance and has moderate to low replaceability.	**Not significant**	**Major**	**Critical**	**Critical**

Table 8-21 Significance of impacts on priority Ecosystem Services

Service	Subcategory	Value rating	Magnitude of impact	Significance of impact
Provisioning				
Food	Collecting wild fruits	Medium	Moderate	Moderate
Food	Hunting	Critical	Moderate	Critical
Food	Fishing	Critical	Major	Critical
Food	Agriculture	Critical	Moderate	Critical
Fuel	Firewood for cooking	Critical	Moderate	Critical
Freshwater	-	Critical	Major	Critical
Natural medicine	Medicinal plants	High	Minor	Moderate
Biological raw materials	Construction materials	Medium	Moderate	Moderate
Abiotic raw materials	Mineral resources	High	Moderate	Major
Regulating				
Seed dispersal and pollination	-	High	Minor	Moderate
Regulation of natural hazard	Forest cover (wind stopper and dust)	Critical	Moderate	Critical
Erosion control	-	Medium	Moderate	Moderate
Pest control	Pest control	High	Moderate	Major
Cultural				
Spiritual values	Sacred forests	High	Moderate	Major
Spiritual values	Cemetery	Critical	Major	Critical
Educational and cultural heritage values	Archaeological artifacts	Medium	Minor	Minor
Ecotourism	-	Medium	Negligible	Not significant
Supporting				
Nutrient cycling processes	-	Critical	Moderate	Critical
Soil formation processes	-	Critical	Moderate	Critical
Photosynthesis	-	Critical	Moderate	Critical

8.5.3 Management and Mitigation Measures and Significance of Impacts after Mitigation

8.5.3.1 Management and Mitigation Measures

A list of priority ecosystem services has been established (Section 8.5.1.3) for which the Project must design mitigation measures that aim to maintain or restore the value and functionality of the service for beneficiaries.

Due to the cross-cutting nature of Ecosystem Services, mitigation of impacts will be captured in the Soil, Water, Biodiversity, Socio-economic, Community Health & Safety, and Cultural Heritage sections of this ESIA document. The following provides a series of mitigation measures more specific to this section and for Ecosystem Services rated Critical:

- Working with the project affected communities to support them in securing safe and sustainable water supplies;
- Develop sustainable agricultural, fishing, and livestock-breeding programmes (e.g., as part of the Community Development Plan), as identified through needs-based assessments and community consultations that aim to diversify and increase production in the Project area through best practice techniques.
- Design and implement an information and awareness programme regarding sustainable harvesting, agriculture, grazing, and conservation of natural resources in partnership with relevant organisations where available and appropriate;
- Undertake appropriate interventions (e.g. nurseries), as identified in needs assessments, to replace lost resources and to harvest and replant species of local significance, particularly medicinal species;
- Protection of soils outside work areas from damage by prohibiting the movement of construction vehicles and equipment outside designated areas (see also Soil Management Plan in **Error! Reference source not found.**);
- Scheduling works with high erosion potential during the dry season wherever possible; and
- Rehabilitating all disturbed land as soon as practical after completion of works (see Conceptual Closure Plan in **Error! Reference source not found.**).

8.5.3.2 Significance of Impacts after Mitigation

Most impacts will be reduced to Major or lower significance (Table 8-22). Where full restoration is not possible, compensation or replacement services should be provided (e.g. cemeteries).

Table 8-22 Significance of Impacts on priority Ecosystem Services after mitigation

Service	Subcategory	Value rating	Magnitude of impact	Significance of impact
Provisioning				
Food	Collecting wild fruits	Medium	Minor	Minor
Food	Hunting	Critical	Minor	Major
Food	Fishing	Critical	Minor	Major
Food	Agriculture	Critical	Minor	Major

Fuel	Firewood for cooking	Critical	Minor	Major
Freshwater	-	Critical	Minor	Major
Natural medicine	Medicinal plants	High	Negligible	Not significant
Biological raw materials	Construction materials	Medium	Minor	Minor
Abiotic raw materials	Mineral resources	High	Moderate	Major
Regulating				
Seed dispersal and pollination	-	High	Minor	Moderate
Regulation of natural hazard	Forest cover (wind stopper and dust)	Critical	Minor	Major
Erosion control	-	Medium	Minor	Minor
Pest control	Pest control	High	Minor	Moderate
Cultural				
Spiritual values	Sacred forests	High	Moderate	Major
Spiritual values	Cemetery	Critical	Moderate	Critical
Educational and cultural heritage values	Archaeological articfacts	Medium	Minor	Minor
Ecotourism	-	Medium	Negligible	Not significant
Supporting				
Nutrient cycling processes	-	Critical	Minor	Major
Soil formation processes	-	Critical	Moderate	Critical
Photosynthesis	-	Critical	Minor	Major

8.6 Landscape and Visual Impact

8.6.1 Assessment context

The visual and landscape assessment has been undertaken in terms of the Guidelines for Landscape and Visual Impact Assessment (2013 edition) provided by the Landscape Institute (UK). In addition, the requirements included in the IFC PS and guidelines will be incorporated into the assessment specifically:

- IFC PS 6 and 8 of 2012 where a project needs to take cognizance of sustainable natural resource management in relation to its landscape and considering sensitivities of cultural and historical landscape sensitivities respectively; and
- Section 1.1 of the IFC Environmental, Health and Safety Guidelines for Mining (2007) which indicates that operations should "prevent and minimise negative visual impacts through consultation with local communities about potential post-closure land use, incorporating visual impact assessment into mine reclamation process.''

The assessment describes in a quantitative and qualitative manner the visual and landscape aspects that could be affected through an analysis of the following:

- The project activities and infrastructure;
- The baseline visual and landscape aspects;
- The sense of place;
- The level of landscape/visual modification (magnitude);
- The area from which the project can be seen, the Zone of Visual Influence (ZVI);
- The capacity of the landscape to visually absorb structures and forms placed upon it; and
- The visual receptor sensitivity.

To determine the significance of potential visual impacts associated with the development it is important to understand the ZVI of the project, the distance and aspects of the project which could potentially be seen, the capacity of the landscape to absorb the change, the sensitivity of the receptors to accommodate the change, the visual character of the landscape and the sense of place which is applicable as formed by receptor perception.

Zone of Visual Influence (ZVI)

A ZVI analysis was carried out to define areas from which the proposed infrastructure would be visible. A ZVI map therefore illustrates the potential visibility of an object in the landscape. The phrase "potential visibility" is used to describe the result because the analysis does not take into account any landscape artefacts such as trees, woodland, buildings etc. The visibility analysis therefore considers the worst-case scenario, using line-of-sight i.e. ignoring vegetation cover and other structures and is based on topography alone. The ZVI also does not take into account the effects of weather and atmospheric conditions in reducing visual range. The ZVI analysis assists the process of identifying possible affected viewers and the extent of the effected environment. The results are not intended to show the actual visibility of an object, they are intended to indicate where the object may be visible from. Actual visibility can only accurately be determined by a site survey since there are a multitude of local variables that may affect lines of sight. On the other hand, a ZVI does show where an object definitely cannot be seen.

Figure 8-5 ZVI of of Waste Rock Dump

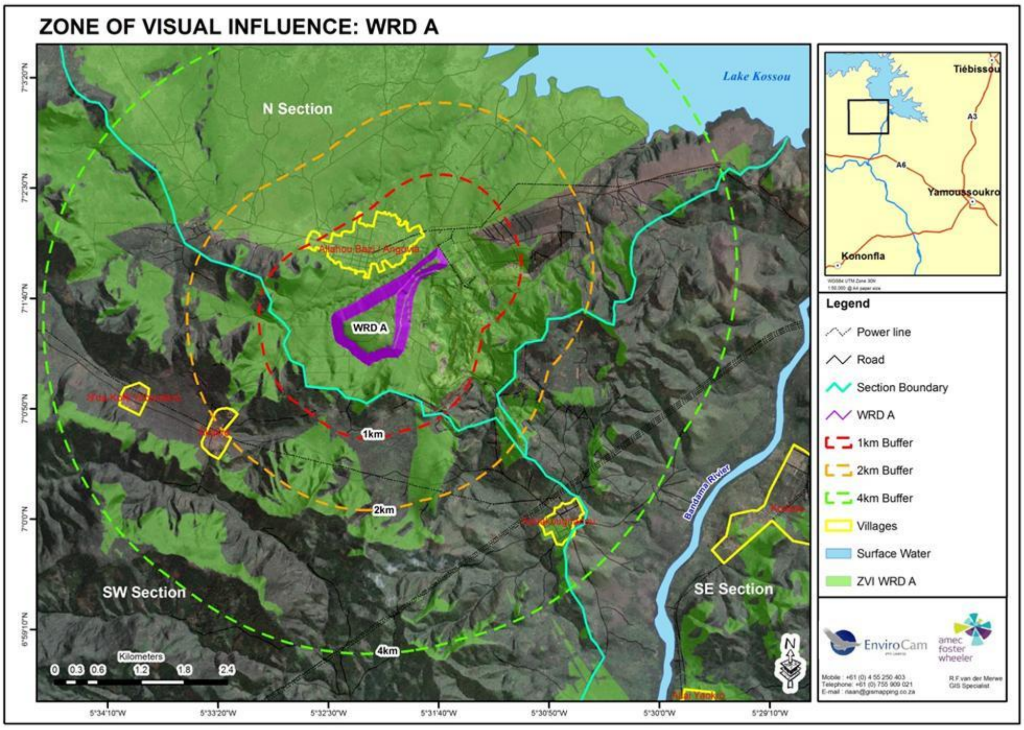
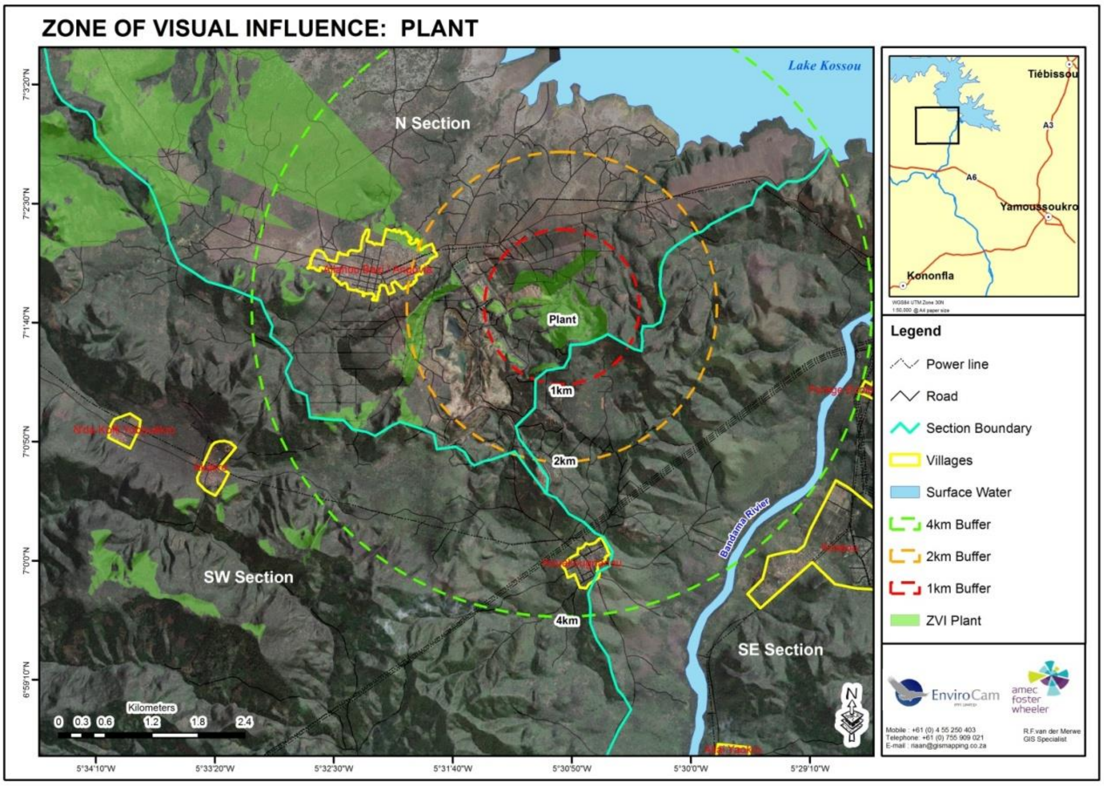


Figure 8-6 ZVI of the plant



8.6.2 Source, Receptors, and Significance of Potential Impacts before Mitigation

Impacts during the construction phase will mainly be associated with the clearance of land, cuts and fills and artificial light.

Characteristics of the process plant from a visual assessment are summarised in the following:

- The Primary Crusher is expected to be approximately 20 m tall;
- The mill area is likely to be open. The top of the mills will be about 20-25 m off the ground;
- The leach tanks will be approximately 15 m tall;
- Two tower cranes are currently foreseen that will be more than 30 m tall; and
- The location of the crusher and plant infrastructure will be behind the waste rock dumps or close to the ROM pad, which effectively limits their visibility.

During the operational phase the main visual impacts will result from the TSF, the WRD, artificial light, the plant and dust associated with the various activities.

- The impact of artificial light is seen as a negative direct impact, with a definite likelihood that the impact will occur. The duration of the impact will be long term until final closure and will affect the wider region and communities. Due to the rural nature, the magnitude of the unmitigated impact will be moderate to high, but as a result of the low receptor sensitivity the impact significance is foreseen to be low.

- The proposed infrastructure (TSF, WRD, plant etc.) will have a definite, direct negative visual impact. The impact will be of a permanent nature and will affect the wider, mainly non-sensitive receptors, which will likely result in a low visual impact should the relevant mitigating measures be implemented.

- The scarring of the landscape through cuts, fills, removal of vegetation, the open pit and dust will have a low significance with the implementation of the required management measures, even though the impacts will be directly negative and will have an influence on the wider non-sensitive receptor environment.

- It is important to note that should the area experience an influx of job seekers and uncontrolled construction of settlements due to shortage of housing in the mine camp or the adjacent villages (mainly Angovia/Allahou Bazi), this will cause significant negative additional visual impacts that will be difficult to manage.

The project and its infrastructure are visible from over half the zone of potential influence, and/or views are mostly unobstructed, resulting in a high visibility. It was determined that the magnitude of the various visual impacts of the proposed Yaoure Project would be High mainly due to high visibility, the proximity of villages/local roads to the proposed infrastructure (view distance), and the moderate visual absorption capability of the surrounding areas. The fact that the visual receptors were rated as being of Low sensitivity resulted that the overall Landscape and Visual Impact will be of Low Negative significance.

With respect to landscape impacts, artisanal mining activities that have continued from historic times give the northern section uniqueness and a distinctive sense of place and may be limited and altered by the proposed expansion of commercial mining activities, thereby changing the cultural transformations and traditions associated with the historic use and habitation of the surrounding area. The construction of the TSF, WRDs and associated infrastructure may change the spatial form and character of the natural landscape and thereby the current uniqueness and distinctiveness of the current landscape character, especially in the northern section.

From the baseline information the area most vulnerable to an alteration of its current sense of place and landscape character is the northern section of the proposed Yaoure Gold Project, mainly due to the scale and extent of the proposed operations.

Expansion of the commercial mining activities will potentially limit and restrict artisanal mining and therefore have a distinct direct impact on the historic sense of place within the northern section.

The change to the fabric and character of the landscape caused by the physical presence of a development of the proposed Yaoure Gold Project will have a direct impact and will disturb a large percentage of the proposed project site directly. The size and scale of the WRDs and TSF will change the topography significantly and as a result alter the current landscape.

The expansion of the mining activities of the Yaoure Gold Project may increase the population growth and expand other associated infrastructure and economic activities, possibly changing the landscape character and sense of place in the south-eastern and south-western sections. Therefore an overall cumulative impact on the current landscape and sense of place is predicted.

8.6.3 Management and Mitigation Measures and Significance of Impacts after Mitigation

Mitigation measures include limited surface disturbance and prompt rehabilitation. These measures are prerequisite conditions if the severity of impact is to be reduced:

- In terms of artificial light it is important that security flood lighting and operational lighting should only be used where absolutely necessary and carefully directed, preferably away from sensitive viewing areas (e.g. nearby village of Allahou Bazi/Angovia and local roads). Wherever possible, lights should be directed downwards and shielded so as to avoid illuminating the sky and minimising light spills.

- Management measures required to mitigate the impacts associated with the TSF, WRD and other infrastructure include concurrent and end-of-life rehabilitation to ensure that the TSF and WRD blend in with the natural landscape. Sufficient screening the infrastructure in the forms of landscaped berms or vegetation screens will be installed and buildings and structures will be painted in colours that will blend in with the natural environment. More details on the landscape design principles to be followed during closure and rehabilitation are provided in Section 8.6.4.

- Effective dust suppression will have to be implemented for air quality and visual reasons.

Assuming all mitigation measures are successfully implemented, the landscape and visual impact is further reduced, especially during the advanced operational phase with concurrent rehabilitation in progress, and into final closure and rehabilitation. The impact significance remains Low to Medium.

With respect to landscape impacts, potential impacts could be mitigated or remediated once operations cease at the end of life of mine with rehabilitation programmes but the scale and extent of the operations will modify the landscape character and sense of place of the surrounding area permanently. Although the spatial extent and magnitude score are relative high, the receptor sensitivity score are low. This will ultimately reduce the significance of the alteration of current landscape character and sense of place impact to a medium significance score and therefore a Medium impact.

8.6.4 Landscaping and Design

The TSF and WRD's be designed with the aim of closure in mind. The design process will specifically address the geometry of the WRDs, especially WRD A. The maximum height, area and shape of the WRDs will be designed with regard to the area of land available, and as far as practical the final angle and shape of the WRDs should blend with the natural landscape, providing that surface stability can be achieved. Where appropriate the TSF and WRDs should have a geometry that is irregular and does not look man-made.

The gradient of the side slopes will be designed to accommodate self-succession of natural vegetation. Long unbroken slopes allow surface runoff to accelerate and may produce erosion gullies. For these reasons it is recommended to design slopes of no greater than 20°, with benches every 7-10 m of vertical height. Slopes below 20° will have reduced erosion hazards and will have a better change for re-vegetation to be successful.

An ecological approach to rehabilitation and vegetative screening measures, as opposed to a horticultural approach to landscaping will be preferred. For example communities of indigenous plants enhance bio-diversity and blend well with existing vegetation. This ecological approach to landscaping costs significantly less to maintain than conventional landscaping methods and is more sustainable. A qualified landscape architect will be consulted for this purpose. It is important that landscaping be done concurrently from the onset of construction and throughout the operational phase and to rehabilitate exposed areas as soon as possible after construction activities are complete. Only indigenous vegetation should be used for rehabilitation/landscaping purposes.

Trees and shrubs can be used to screen structures and break stark contrasting lines if carefully planned and positioned. Where structures are silhouetted when viewed from local roads, the harsh lines can be broken by planting fast growing indigenous trees along the edges of the WRDs and TSF. Encouraging vegetation growth in disturbed areas can reduce the visual scarring of the landscape and potentially reduce the visual impacts on potential visual receptors. The re-vegetation of the disturbed areas around the proposed infrastructure, including on the WRDs, during the operational phase will be considered only if it does not interfere with operations or pose a risk to the health and safety of people and animals.

The TSF and WRD geometry and design will be optimised considering not only construction but rehabilitation and re-vegetation costs and to provide suitable final land forms for the establishment of mixed native woodland thereby minimising the long term visual impact of the infrastructure by creating acceptable landforms compatible with the adjacent landscape. Aprofessional landscape architect should assist with the final design and rehabilitation plan for the WRDs and TSF.

8.6.5 Summary of landscape and visual impacts

See table overleaf.

Table 8-23 Summary of landscape and visual impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO	Visual and landscape disturbance	Clearance of land, cuts and fills and artificial light	1	2	2	Low
OP	Visual disturbance	Main visual impacts will result from the TSF, the WRD, artificial light, the plant and dust associated with the various activities	1	3	3	Medium
CO/OP	Visual disturbance	Should the area experience an influx of job seekers and uncontrolled construction of settlements due to shortage of housing in the mine camp or the adjacent villages (mainly Angovia/Allahou Bazi)	1	2	2	Low
OP/CL	Landscape, "Sense of place"	Change of landscape character, mainly in the south-eastern and south-western sections, due to large mine waste facilities and Project infrastructure. This may partly be mitigated in the Closure phase and possibly during the operations phase by concurrent rehabilitation.	1	3	3	Medium

8.7 Air Quality

8.7.1 Assessment Context

8.7.1.1 General

Protection of human health

The air quality criteria to be used in the assessment are those recommended by the International Finance Corporation (IFC) of the World Bank Group (2007). These have been essentially derived from the Air Quality Guidelines set by the World Health Organisation (2005), and contain recommendations for ambient air quality standards and emission limit values for combustion plant. These standards are for the protection of human health and incorporate a number of safety factors, to take account of uncertainties in the various supporting scientific and medical studies from which the standards are derived.

The principal pollutants that will be emitted will be from the combustion of hydrocarbon fuels by equipment on the operational mine site and occasional back-up generator operation, which are most likely to contribute to exceedances of the relevant air quality standards and guideline values (see Section 2.3.5) include the following:

- Nitrogen oxides (NO_X, which comprises nitric oxide (NO) and nitrogen dioxide (NO_2));
- Particulate matter (PM_{10}: particles with an aerodynamic diameter of less than 10 micrometres (µm), and $PM_{2.5}$: particles with an aerodynamic diameter of less than 2.5 µm);
- Sulphur dioxide (SO_2); and
- Carbon monoxide (CO).

In addition, there is the potential for the generation of airborne dust and particulates as a result of specific activities being undertaken on site, which, owing to increased deposition levels, may affect local amenity and quality of life.

This air quality assessment therefore focuses on the potential impacts associated with these pollutants. A brief description of each pollutant is given below in Table 8-24.

Table 8-24 Summary of the air pollutants included in the assessment

Pollutant	Description and effect on human health and the environment	Principal sources
Oxides of Nitrogen (NO_X)	Nitrogen dioxide (NO_2) and Nitric oxide (NO) are both collectively referred to as oxides of Nitrogen (NO_X). It is NO_2 that is associated with adverse effects on human health. Most atmospheric emissions are in the form of NO which is converted to NO_2 in the atmosphere through reactions with Ozone. The oxidising properties of NO_2 theoretically could damage lung tissue, and exposure to very high concentrations of NO_2 can lead to inflammation of lung tissue and can affect the ability to fight infection. The greatest impact of NO_2 is on individuals with asthma or other respiratory conditions, but consistent impacts on these individuals only occurs at levels of greater than 564 μgm^{-3}, much higher than typical ambient concentrations recorded in the study area.	All combustion processes produce NO_X emissions, and the principal source of NO_X is road transport. In Africa, the high rates of urbanisation, coupled with low incomes, have resulted in the importing of older used vehicles in recent years, the use of cheap two-wheeled vehicles and cheap fuel, and the postponement of vehicle maintenance, has led to increased emissions of NO_x/NO_2.
Particulate Matter (PM_{10} and $PM_{2.5}$)	Particulate matter is the term used to describe all suspended solid matter. Particulate matter with an aerodynamic diameter of less than 10 µm (PM10) is the subject of health concerns because of its ability to penetrate and remain deep within the lungs. The health effects of particles are difficult to assess, and evidence is mainly based on epidemiological studies. Evidence suggests that there may be associations between increased PM10 concentrations and increased mortality and morbidity rates, changes in symptoms or lung function, episodes of hospitalisation or medical consultations. Recent reviews by the World Health Organisation (WHO) and Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to a finer fraction of particles (PM2.5) give a stronger association with the observed health effects. PM2.5 typically makes up around two-thirds of PM10 emissions and concentrations.	Typically from road transport, industrial processes and electricity generation sources. Other pollutants, including NO2 and SO2, have the potential to form secondary particulates which are often smaller than PM10. In Africa, high concentrations of particulate matter are often associated with prolonged forest fires and local emissions of particles from the use of poor-quality fuels. Natural sources include wind-blown particulates from dry open areas and unpaved roads.
Sulphur Dioxide (SO_2)	At high concentrations SO2 is a potent bronchoconstrictor and asthmatic individuals are more susceptible. It is likely that SO2 contributes to respiratory symptoms, reduced lung function and rises in hospital admissions. Exposure to high levels of SO2 over a long	The principal source of SO2 is the combustion of fossil fuels containing sulphur. The more common use of high S-content fuels in Africa often leads to elevated ambient concentrations of SO2.

Pollutant	Description and effect on human health and the environment	Principal sources
	period can result in structural changes in the lungs and may enhance sensitisation to allergens.	
Carbon Monoxide (CO)	The toxicity of CO results in it binding avidly to haemoglobin and thus reducing the oxygen carrying capacity of the blood. In very high doses, the restriction of oxygen to the brain and heart can be fatal. At lower concentrations, CO can affect higher cerebral function, heart function and exercise capacity.	The principal source of CO is emissions from combustion processes, including vehicles.
Dust	Particles typically in the size range 1 to 75 µm in aerodynamic diameter. Increased deposition can result in regular and persistent dust annoyance, which may affect local amenity and quality of life.	Within Cote d'Ivoire, the principal source of dust will come from the action of vehicles and the wind on unpaved roads/tracks and earthworks associated with construction and operational activities.

As discussed in Section 2.8.3, the IFC's EHS Guidelines (2007) are technical references with general and industry-specific examples of good international industry practice. In relation to air quality, Section 1.1 of the IFC EHS Guidelines states:

"Projects with significant[7] sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimise impacts by ensuring that:

- *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines or other internationally recognised sources;*
- *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25% of the applicable air quality standards to allow additional, future sustainable development in the same airshed."*

As the project will be carried out in accordance with international standards which are more stringent than the Côte d'Ivoire air quality standards in Table 2-2, for the purposes of this assessment, criteria have therefore been taken from relevant WHO international

[7] Significant sources of point and fugitive emissions are considered to be general sources which, for example, can contribute a net emissions increase of one or more of the following pollutants within a given airshed: PM_{10}: 50 tons per year (tpy); NO_x: 500 tpy; SO_2: 500 tpy; or as established through national legislation; and combustion sources with an equivalent heat input of 50 MWth or greater. The significance of emissions of inorganic and organic pollutants should be established on a project-specific basis taking into account toxic and other properties of the pollutant.

Air Quality Guideline (AQG) values and European Union (EU) Air Quality Standards (AQSs).

WHO AQGs offer global guidance to policy-makers on reducing the health impacts of air pollution. The guidelines, first produced in 1987 and updated in 1997, previously adopted a European scope, whilst the current 2005 guidelines are applied globally. They recommend revised limits for the concentration of selected air pollutants including particulate matter (PM), ozone (O_3), NO_2 and SO_2 applicable across all WHO regions. In addition to the guideline values, the AQGs give interim targets (ITs) related to outdoor air pollution, for each air pollutant, aimed at promoting a gradual shift to lower concentrations. If these ITs are achieved, reductions in risks for acute and chronic health impacts from air pollution would be expected, but the ultimate objective should be progress towards the guideline values. Although these guidelines are neither standards nor legally binding criteria, they are designed to offer guidance in reducing the health impacts of air pollution based on expert evaluation of current scientific evidence.

EU policy on air quality aims to develop and implement appropriate instruments to improve air quality within the EU member states. EU Directive 2008/50/EC, which came into force in June 2008, merges most of the existing air quality legislation into a single directive (the exception is the fourth "Daughter Directive" under the 1996 Framework Directive (96/62/EC)). This reorganisation of the legislation did not include a change to the existing AQSs. It introduces a new framework for $PM_{2.5}$ (fine particles), including the limit value and exposure related targets with a period of two years provided to all EU Member States to transpose the new Directive. The introduction of this framework was based on increasing evidence that this size of particle can be more closely associated with observed adverse health impacts than PM_{10}. The AQSs relate to ambient pollutant concentrations in the air and the limits are set on the basis of medical and scientific evidence reviewed by the Expert Panel on Air Quality Standards (EPAQS) and the WHO as to how each pollutant affects human health. Above these limits, sensitive members of the public (e.g. children, the elderly and the infirm) may experience adverse health impacts. Although only legally binding for EU member states, the EU AQSs are based upon the current scientific position with regards to health effects of air pollutants and are thus considered to be of relevance to this assessment.

Table 8-25 summarises the EU standards and WHO guideline limit values for those pollutants that are of relevance to this study.

Table 8-25 WHO Air Quality Guidelines and EU Air Quality Standards

Pollutant	Averaging Period	Limit Value (µg/m³)	
		WHO AQG	EU AQS
NO_2	Annual mean	40	40
	1-hour mean	200	200[A]
CO	Max 8 hour mean	10,000	10,000
PM_{10}	Annual mean	20	40
	24-hour mean	50	50[B]
$PM_{2.5}$	Annual mean	10	25
	24-hour mean	25	-
SO_2	Annual mean	50	-
	24-hour mean	-	125[C]
	1-hour mean	-	350[D]
	10-minute mean	500	-

[A] Not to be exceeded more than 18 times per year.
[B] Not to be exceeded more than 35 times per year.
[C] Not to be exceeded more than 3 times per year.
[D] Not to be exceeded more than 24 times per year.

With regard to dust and associated annoyance, there are no statutory limit values for dust deposition above which 'nuisance' or 'annoyance' is deemed to exist. Nuisance/annoyance is a subjective concept and its perception is highly dependent upon the existing conditions and the change to air quality conditions which has occurred (i.e. increases in pollutant concentrations or dust deposition rates relative to background levels).

In terms of dust deposition, it is proposed to utilise the dust nuisance criteria developed by the Government of South Africa (RSA, 2005), reproduced below in Table 8-26, as these are considered to be appropriate in terms of the prevailing climate and existing sources and levels of dust deposition.

Table 8-26 Dust Deposition Criteria

Dust Deposition Rate, mg/m²/day	Effects
< 250	Slight
250 – 500	Moderate
500 – 1,200	Heavy
>1,200	Very Heavy

Protection of Flora and Fauna

It is well-established that certain air pollutants, such as nitrogen oxides, sulphur oxides, ammonia, hydrogen fluoride, hydrogen chloride and ozone, can have direct and indirect effects upon vegetation, through a combination of direct diffusion of gases into foliage and acidic and nitrogen deposition into the soils. However, the research underpinning these impacts is generally restricted to vegetation in temperate zones of the world and the likely effects of these air pollutants on tropical vegetation in Central Africa are not clearly known. Notwithstanding this, concerns have been expressed by the scientific community over the effects of air pollutants upon tropical vegetation, as follows:

> *"Northern Africa could be less sensitive due to neutral or alkaline soils, while equatorial Africa could become acidified more easily due to the generally low pH and CEC (cation exchange capacity) in soils. Here too, areas around large, fast-growing population centers, such as parts of Nigeria, could be more sensitive to acidification"* (Rodhe et al, 1988).

However, no specific criteria could be sourced from the technical literature for use in this current assessment.

With regard to the potential effects of dust deposition upon vegetation, direct physical effects of mineral dusts on vegetation appear to become significant only at relatively high surface loads (e.g. >7 g/m^2) (Farmer, 1993) whereas the chemical effects of reactive materials such as cement dust may become evident at 2 g/m^2, whilst particulate sulphates and nitrates may have indirect effects on ecosystems (Grantz et al., 2003).

Dust deposited on a leaf surface alters its optical properties, particularly the surface reflectance in the visible and short wave infrared radiation range (Eller 1977; Hope et al., 1991; Keller and Lamprecht 1995), and the amount of light available for photosynthesis.

Dust accumulating on leaf surfaces may interfere with gas diffusion between the atmosphere and the leaf. Sedimentation of coarse particles affects the upper surfaces of leaves more, while finer particles affect lower surfaces. In dusty environments, for those plant species having stomata set in grooves, the covering of wax on the stomata may be affected to a lesser degree than species in which the stomata are located on the outer surface of the leaf (Santosh, 2012).

Such levels of deposition referred to above, in the g/m^2 range, are only usually reached within the confines of mine pits, rather than in the surrounding areas. In addition, during the wet season, any particulate matter deposited upon the surfaces of vegetation would be quickly removed from the upper surfaces of vegetation leaves.

Overall, while the subject of dust effects upon vegetation has been reviewed by a number of researchers, it has not been possible, to date, to identify a widespread threat to ecosystem function due to un-speciated particulate matter. Therefore, no established criteria exist for the protection of plants from deposited dust.

Although the Amec Foster Wheeler biodiversity and ecology studies identified several species of aquatic and terrestric animal species in proximity to the study area (see Section 6-8), no information exists on the sensitivity of these species to dust/air pollutants and it is therefore considered that the potential air quality effects pose no concern to these species. Furthermore, no sensitive flora or crops were identified within proximity to the site where dust or pollutant deposition could occur at a rate sufficient to cause significant effects. Biodiversity and ecological receptors are therefore not considered further in the assessment of air quality effects.

8.7.1.2 Scope of Assessment

This section of the report describes the technical methodology that has been applied to enable the assessment of the potential effects upon air quality of the proposed activities and operations at the mine. In summary, the method applied consists of the following elements:

- Identification, characterisation and enumeration of emission sources – the emissions inventory;
- Spatial assignment of the emission sources to the geographical areas of the mine and site;
- Selection of an appropriate atmospheric dispersion model that is capable of simulating dilution, dispersion and deposition of pollutants emitted into the atmosphere;
- Selection of locally-measured meteorological parameters and compilation of annual data sets that can be used to drive the dispersion model;
- Identification of the locations of sensitive receptors, at which points air pollutant concentrations and deposition rates can be calculated by the model;
- Entering all the above information into the model input files; and
- Taking the output concentration and deposition data, combining it with existing background air quality data and assessing the results against the air quality assessment criteria (the IFC Guidelines/EU Limit Values and dust deposition criteria) contained in Table 8-25 and Table 8-26 above.

8.7.1.3 Identification and Characterisation of Emission Sources

Air quality impacts of the Project will be by far greatest during its operational phase. The peak operational phase represents the greatest number of on-site vehicle movements and, thus, the highest level of exhaust emissions to air. It also represents the phase of greatest fugitive dust emissions. The air quality assessment therefore focuses on the operational phase of the project only, as any air quality impacts during construction will be less significant.

There will be a large number of different sources of air pollutant emissions from the Yaoure Project during the operational phase. These can be divided into two basic categories:

- Emissions of diesel combustion products from mobile plant, machinery and vehicles, including nitrogen oxides (NO_x), sulphur dioxide (SO_2), fine particulate matter (PM_{10}, $PM_{2.5}$) and carbon monoxide (CO); and

- Fugitive dust emissions from blasting, materials handling, wind erosion of stockpiles and vehicle movements on unmade roads and haul routes, including coarse nuisance dust which deposits relatively close to its sources and fine particulate matter, which is carried for greater distances in the atmosphere.

As discussed in Section 3.3.9, electricity will be sourced from the power station at Kossou barrage. On-site power generation will therefore be minimal and emissions from diesel combustion by generators is not considered further.

Plant and Vehicle Complements

As detailed in the report section immediately above, the worst case air quality and dust impacts will occur during the periods of peak operation at the Yaoure site. Impacts from the site construction will therefore be less than those for operation. The detailed modelling assessment focuses on the peak operational period only as this represents the worst case impacts.

Table 8-27 below details the plant and vehicle component identified as the largest exhaust emitters during the peak operation period for the Yaoure Project.

Table 8-27 Plant and Vehicle Complement Considered in Air Quality Assessment

Plant/Vehicle Type	Numbers Operating	Comment
CAT-785C	34	Primary Trucks
CAT-6040E	4	Primary Shovels
CAT 992	2	Primary Loaders
Allight Lighting Plants	7	Lighting Plant

Emissions Calculations

<u>Exhaust Gas Emissions: On-site Vehicles</u>

In order to calculate the emissions of combustion gases and fine particulate matter from diesel combustion from the above plant and vehicles, assumptions were made, including:

- The engine net power rating of the plant item or vehicle, based on technical data sheets;

- Operation of plant 24 hours a day, seven days a week; and

- As a conservative assumption, $PM_{2.5}$ emissions were assumed to be the same as PM_{10} emissions.

Plant and vehicle emission factors for NO_x, PM_{10} and $PM_{2.5}$ were sourced from the United States Environmental Protection Agency (USEPA) Non-Road Compression-Ignition Engines, Exhaust Emission Standards (USEPA, 2013) as engine data sheets were provided with USEPA emission class information. Summaries of the emissions calculated for each of the scenarios are presented in Table 8-28 and the details underlying these calculations are contained in **Error! Reference source not found.**.

Table 8-28 Summary of Plant and Vehicle Emissions

Plant/Vehicle Type	Number Operating	Total emissions (g/s)		
		NOx	$PM_{2.5}$	PM_{10}
CAT-785C	34	87.323	5.126	5.126
CAT-6040E	4	shovels are equipped with electric drives, so that there are no air emissions		
CAT 992	2	2.158	0.067	0.067
Allight Lighting Plants	7	0.073	0.008	0.008

SO_2 emissions were calculated using the diesel consumption of 1,750 m^3 per month and an assumed sulphur content of 0.5% (5,000 ppm), giving a total SO_2 emission of 5.9 g/s.

Fugitive Dust Emissions

The emissions of fugitive dust from the following sources were estimated using procedures recommended by an Australian Government publication (Australian Government, 2012), which contains fugitive nuisance dust and PM_{10} emission factors for the following sources:

- Blasting, drilling, winning and excavation of ore and overburden;
- Materials handling;
- Crushing and dry milling;
- Movement of vehicles on unmade roads; and
- Wind erosion of waste rock and tailings across the site generally;

The calculations of fugitive emissions are based upon those contained in the USEPA AP-42 publication (USEPA, 2003-11), which is widely used around the world to estimate emissions of this type. $PM_{2.5}$ emissions were assumed to be 10% of those for PM_{10} in accordance with USEPA guidance (Pace, 2005).

Summaries of the calculated emissions for the Yaoure Project during peak operation are contained in Table 8-29. Results are presented as both

- "Unmitigated", assuming no active control or management of dust emissions (Section 8.7.2);
- And also as "mitigated", assuming that industry standard control and management practices are imposed and taking into account the screening provided by WRD A (Section 8.7.3).

Table 8-29 Summary of Fugitive Dust and PM_{10} Emissions

Dust source	Unmitigated emissions (g/s)		Emission Control	Emission reduction (%)	Mitigated emissions (g/s)	
	TSP	PM_{10}			TSP	PM_{10}
Crushing	41.22	4.12	None	0%	41.22	4.12
Excavation	66.59	33.30	None	0%	66.59	33.30
Loading trucks	12.37	6.18	Water sprays	50%	6.18	3.09
Unloading onto stockpile	12.37	6.18	Water sprays	50%	6.18	3.09
Dump truck	69.04	20.40	Water sprays on roads	50%	34.52	10.20
Shovel	18.89	4.56	No control	0%	18.89	4.56
Wheeled Loader	11.75	3.47	No control	0%	11.75	3.47
Blasting	2.32	1.20	Safety Berm/Below Ground	30%	1.63	0.84
Wind erosion WRD A	12.44	6.22	Safety Berm/Below Ground	30%	12.44	6.22
Wind erosion WRD B	9.44	4.72	Safety Berm/Below Ground	30%	6.61	3.31
Wind erosion WRD C	10.33	5.17	Safety Berm/Below Ground	30%	7.23	3.62
Wind erosion ROM (Run of Mine) Pad	1.56	0.78	Safety Berm/Below Ground	30%	1.09	0.54
Wind erosion LGO (Low Grade) Stockpile	1.00	0.50	Safety Berm/Below Ground	30%	0.70	0.35
Wind erosion TSF	23.78	11.89	Safety Berm/Below Ground	30%	16.64	8.32
Wind erosion Pit	17.78	8.89	Safety Berm/Below Ground	30%	12.44	6.22
Total unmitigated	**310.88**	**117.58**	**Total mitigated**		**244.13**	**91.26**

From the above table, it can be seen that the major sources of fugitive dust and PM_{10} emissions are the excavation process, crushing and dump truck movements on exposed surfaces, which would be contained within the pit area.

With the application of standard best practice dust management and control measures, the total fugitive dust emissions are reduced by 21%. The nature and individual effectiveness of these measures is discussed below in Section 8.7.3. Actual emissions would be further reduced by natural dust suppression during the wet season.

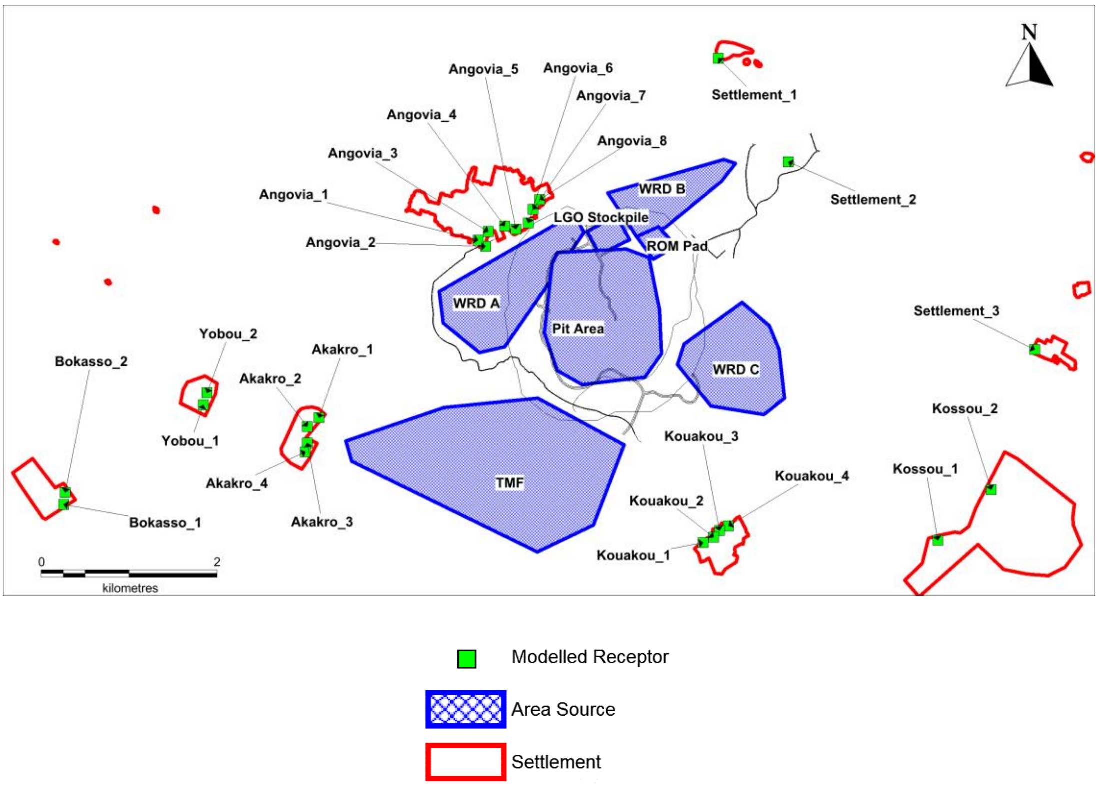
8.7.1.4 Spatial Assignment of Emission Sources

The operational activities of the Yaoure Project are located across a number of different places in the project area. These have been modelled as area sources.

Activities at the pit have been assumed to consist of excavation and blasting of rock and ore followed by transportation to either the ore processing facility or the WRDs. The total emissions per blast have been calculated from an area per blast of 9,410 m^2. The total emissions have been averaged across the day to represent the emissions of one blast per day. Blast emissions have been incorporated into the pit area source as the open pit will have a depth of approximately 300 m below surface level, so emissions are unlikely to rise significantly above surface level. To take account of the differing heights of sources and the complicated air movements that are likely to occur, a surface roughness value of 1 m has been used in the model.

Emissions from the area covering the pit area source therefore include the plant emissions and material handling fugitive emissions detailed above. Separate wind erosion emission factors are associated with the individual WRDs, ROM Pad, LGO Stockpile and TSF (which has been included as a source as a conservative approach assuming the sludge dries). The diagram of the model is shown in Figure 8-7.

Figure 8-7 Air Quality Dispersion Model Layout



8.7.1.5 Dispersion Model Selection

The IFC Guidance (2007) states

> *"The dispersion model applied should be internationally recognised, or comparable. Examples of acceptable emission estimation and dispersion modelling approaches for point and fugitive sources are included in Annex 1.1.1. These approaches include screening models for single source evaluations (SCREEN3 or AIRSCREEN), as well as more complex and refined models (AERMOD OR ADMS). Model selection is dependent on the complexity and geomorphology of the project site (e.g. mountainous terrain, urban or rural area)."*

As the Yaoure Project involves a plethora of different sources emitting air pollutants, the ADMS version 5 model[8] (ADMS 5) has been selected for use in this assessment.

In any modelling study, there will be a degree of uncertainty in the model results. To allow for these uncertainties, a conservative approach has been adopted in this study where appropriate, involving conservative emissions estimation techniques.

[8] *http://www.cerc.co.uk/environmental-software/ADMS-model.html*

8.7.1.6 Meteorological Data

The ADMS model requires annual data sets of hourly sequential meteorological data, encompassing wind speed, wind direction, ambient temperature, cloud cover in oktas[9] and relative humidity. Meteorological data recorded at Yamoussoukro Airport meteorological station, approximately 35 km to the south-east of the Project area, has been used in the ADMS modelling assessment. As a complete year of data in the correct format was not available, the data used is a composite of the available data for 2012, 2013 and 2014.

8.7.1.7 Identification of Sensitive Receptors

A number of sensitive receptor locations site were identified. These represent the closest points of human habitation to the Yaoure Project.

Table 8-30 contains a summary of the discrete sensitive receptors and their UTM co-ordinates.

Table 8-30 Locations of Sensitive Receptors

Receptor number	Name	UTM, X (m)	UTM, Y (m)
1	Angovia_1	219658	777975
2	Angovia_2	219739	777904
3	Angovia_3	219773	778074
4	Angovia_4	219957	778135
5	Angovia_5	220086	778099
6	Angovia_6	220226	778170
7	Angovia_7	220279	778327
8	Angovia_8	220358	778434
9	Akakro_1	217845	775956
10	Akakro_2	217713	775853
11	Akakro_3	217713	775665
12	Akakro_4	217689	775562
13	Yobou_1	216527	776103
14	Yobou_2	216566	776237
15	Bokasso_1	214937	774968
16	Bokasso_2	214956	775102
17	Kouakou_1	222217	774534
18	Kouakou_2	222339	774592
19	Kouakou_3	222403	774670
20	Kouakou_4	222506	774723
21	Kossou_1	224889	774560
22	Kossou_2	225497	775133
23	Settlement_1	222390	780043
24	Settlement_2	223186	778864
25	Settlement_3	225993	776729

[9] A manual observation technique for estimating the proportion of cloud cover in the sky, based upon dividing the visible skyscape into eight equal areas and noting the extent of cloud present.

8.7.1.8 Background Air Quality Levels used in the Assessment

As detailed in Section 6.8, a three month air quality monitoring survey has been undertaken at receptors close to the project site. This assessment has therefore utilised the monitored data for use as background pollutant levels. As a worst case approach the background level has been assumed to be the same as the maximum three month average at any of the monitored receptors covered by the modelled area. Table 8-31 shows the selected background levels adopted for each of the pollutants.

Table 8-31 Background Air Pollutant Levels used in the Assessment

Air Pollutant	Project Area Background	Background Location used
Nitrogen dioxide	6.9 µg/m^3	Allahou-Bazi
Sulphur dioxide	3.0 µg/m^3 [A]	Kouakou Gnanou
PM_{10}	18.3 µg/m^3	Allahou-Bazi
$PM_{2.5}$	8.1 µg/m^3	Allahou-Bazi
Carbon monoxide	0 µg/m^3 [B]	
Deposited dust	512.6 mg/m^2/day	Allahou-Bazi

[A] In the absence of reliable monitoring data, typical concentration in rural locations such as this used
[B] Not monitored, but CO concentrations generally very low in locations such as this

It is not technically rigorous to add predicted short-term or percentile concentrations to ambient background concentrations not measured over the same averaging period, since peak contributions from different sources would not necessarily coincide in time or location. Without hourly ambient background monitoring data available it is difficult to make an assessment against the achievement or otherwise of the short-term AQG/AQS. For the assessment, conservative short-term ambient levels have been derived by applying a factor of two to the annual mean background data as per the recommendation in the UK Environment Agency Horizontal Guidance H1 Annex (f).

8.7.1.9 Atmospheric Chemistry

All the air pollutants considered in this assessment were assumed to behave conservatively in a steady state within the modelling domain, with the exception of nitrogen dioxide, which, in simple terms, is produced by atmospheric chemical reactions between NO (nitric oxide) and ozone (O_3).

Oxides of nitrogen (NO_x) emitted from diesel-powered combustion sources such as the plant, machinery and vehicles to be deployed in this project are mainly in the form of nitric oxide (NO), with a relatively small proportion in the form of nitrogen dioxide (NO_2) – typically 5%. Nitric oxide is less potentially harmful than nitrogen dioxide and it is nitrogen dioxide that is associated with adverse effects upon human health. Nitric oxide is oxidised in the atmosphere to form nitrogen dioxide. The reverse process converting nitrogen dioxide to nitric oxide also takes place in the atmosphere. In the immediate vicinity of a source of combustion gases, conversion from nitric oxide to nitrogen dioxide does not proceed to near completion. This is because of three factors:

- Firstly, the reaction between nitric oxide and ozone (the main atmospheric oxidant) is not instantaneous, and dispersion away from the closest receptors will take place while this reaction is going on;
- Secondly, the amount of oxidants in the atmosphere available to convert nitric oxide to nitrogen dioxide is limited. Once the immediately available oxidants have been consumed, further reaction will be limited by the extent of atmospheric mixing; and
- Thirdly, there is a competing atmospheric process by which nitrogen dioxide is converted back to nitric oxide in the presence of sunlight.

Whilst there are a number of atmospheric chemistry models that purport to calculate the conversions from NO to NO_2 (and vice versa), the results from such models are uncertain and also require detailed input data on sunshine amounts, ozone concentration and background continuous NO_x and NO measurements. In the absence of such data, accepted practice is to assume that, for annual mean NO_2 concentrations, up to 70% of the total NOx emission will be oxidised to NO_2. For short-term averaging periods, it is accepted that a maximum of 35% conversion of the total NO_x emission to NO_2 should be used. On this basis, the assessment has assumed these worst case NO_2 production figures.

8.7.2 Potential Impacts before Mitigation

8.7.2.1 Pollutant Concentrations Resulting from On-site Operational Activities

A summary of the results of the assessment is contained in Table 8-32 below for the 25 sensitive receptor locations detailed in Table 8-30.

For the sake of brevity in this chapter, the maximum concentration predicted at any of the 25 sensitive receptors is tabulated. In all cases, the maximum is predicted at either receptor Angovia_6 or Angovia_7. These receptors are the closest to the project activities. Detailed results are contained in **Error! Reference source not found.**

In terms of the abbreviations in the results tables, “PC” is the Project Contribution, that is, the change in the concentration of a specific air pollutant that occurs as a result of operation of the Project. “PEC” is the Predicted Environmental Concentration, which is equal to the Project Contribution plus the existing background concentration of an air pollutant in the Project area.

Table 8-32 Summary Maximum Pollutant Concentration Results, pre-mitigation

Pollutant	Averaging period	Air Quality Guideline (AQG) ($\mu g/m^3$)	Back-ground conc. ($\mu g/m^3$)	PC* ($\mu g/m^3$)	PEC* ($\mu g/m^3$)	PC* / AQG (%)	PEC* / AQG (%)
CO	Maximum 8 hour mean	10,000	n/a	5842.9	n/a	58.4%	n/a
SO_2	Annual Mean	50	3.0	0.5	3.5	0.9%	6.9%
	10 Minute Mean	500	6.0	357.8	363.8	71.6%	72.8%
NO_2	Annual mean	40	6.9	4.9	11.8	12.2%	29.5%
	Maximum 1 hour mean	200	13.8	**1698.9**	**1712.7**	**849.4%**	**856.3%**
	99.79 percentile 1 hour mean	200	13.8	128.1	141.9	64.1%	71.0%
PM_{10}	Annual mean	20	18.3	9.9	**28.2**	49.4%	**140.9%**
	Maximum 24 hour mean	50	36.6	**974.8**	**1011.4**	**1949.6%**	**2022.8%**
	90.41 percentile 24 hour mean	50	36.6	14.1	**50.7**	28.1%	**101.3%**
$PM_{2.5}$	Annual mean	10	8.1	1.4	9.5	13.5%	94.5%
	Maximum 24 hour Mean	25	16.2	**142.9**	**159.1**	**571.6%**	**636.4%**

* PC – predicted contribution from mining activities; PEC – predicted environmental concentration = PC plus background.

It can be seen that none of the IFC Air Quality Guidelines for CO and SO_2 are predicted to be exceeded at any of the 25 sensitive receptor locations selected, even including the contribution from existing background air quality. The maximum 1-hour NO_2, annual average and daily mean maximum PM_{10} and daily mean maximum $PM_{2.5}$ guidelines are predicted to be exceeded.

8.7.2.2 Dust Deposition from Onsite Operational Activities

Table 8-33 contains an assessment of the maximum predicted dust deposition rates expected at any of the sensitive receptor locations, detailed results for all receptors are included in **Error! Reference source not found.**.

Table 8-33 Maximum Predicted Dust Deposition at Sensitive Receptors, pre-mitigation

Pollutant	Averaging period	Deposition criterion ($mg/m_2/day$)	PC ($mg/m^2/day$)	PC / AQG (%)
TSP	Total daily deposition	250	22.4	9.0%

It can be seen that there is predicted to be a dust deposition level in the slight category, as detailed in Table 6-39, at all sensitive human receptors. The contribution from the Yaoure project accounts for up to 9.0% of the most stringent criterion at a sensitive receptor. Dust deposition is predicted to be slight at worst at the sensitive receptors near to the project. In view of the existing high dust deposition in the area, it is not considered likely that this additional deposition will be perceptible.

8.7.2.3 Uncertainties in the Modelling Process

There are uncertainties inherent in any dispersion modelling study, as the dispersion model code is an approximation to reality. However, validation studies have shown that, for the prediction of annual mean pollutant concentrations, a precision of around +/- 30% is generally achieved. For shorter-term concentrations (daily/hourly) less precision is achieved.

For fugitive dust emissions, there is a considerable level of uncertainty in the estimation of emissions, as these are subject to variation as a result of many influences, and it is likely, in our experience, that the AP-42 method tends to over-estimate emissions by a factor of between 2 and 3 times the true level. This has been based upon a combined construction dust modelling and monitoring study carried out for the Terminal 5 airport development at Heathrow, UK. Accordingly, the results above should be regarded as the worst-case.

8.7.2.4 Significance of Impacts

Air pollutant impacts from operational activities at the Yaoure project site result in a Moderate level of impact when considering the criteria outlined in Table 8-25. Although impacts from the site are likely to be present for a period of longer than 10 years, the project will not cause an irreversible air quality impact and pollutant concentrations should remain within the IFC AQGs for SO_2 and CO. NO_2, PM_{10} and $PM_{2.5}$ will remain within the EU AQSs. Project contribution dust deposition levels will remain within the most stringent category (less than 250 $mg/m^2/day$) as defined by the Government of South Africa at all human receptors. The sensitivity level of the local receptors is Medium in relation to impacts from air quality as there are no designated ecological sites/ habitats in relation to air quality, but there are a number of settlements, but these are already partially degraded with respect to the high dust deposition levels.

Application of the matrices in Section 7.2 results in a Medium level of significance for impacts from onsite operational activities on air pollutants.

8.7.3 Management and Mitigation Measures and Significance of Impacts after Mitigation

8.7.3.1 Post-mitigation model results

Given that all air quality impacts associated with the Project have been identified to be of Medium significance, mitigation measures are therefore recommended to reduce the impact of the Project.

The project has been planned to reduce emissions where possible. For example, the primary shovels will be equipped with electric drives, so that they do not make any emissions to air. The most important mitigation measure that will suppress transmission of gaseous pollutants, dust and particulates from the Project site to the nearest sensitive receptors in Angovia/Allahou-Bazi will be the erection of the 40 m high safety berm between the open pit and the settlement. The safety berm will be integrated into WRD A and consist of waste rock which will be profiled and vegetated.

The following best practice methods and mitigation measures would also be implemented to minimise the predicted air quality impacts, with specific focus given to measures that could be implemented to minimise the dust and particulate matter impacts that may potentially be generated by Project activities.

Error! Reference source not found. provides details of the Air Quality Management Plan (AQMP) for the site, which would be applied throughout the Project to help minimise potential air quality impacts.

Best practice international guidance control methods and mitigation measures that will be implemented to manage dust and PM_{10} emissions during the Project, and to ensure associated impacts are prevented in areas in proximity to the site, are presented within the AQMP.

The AQMP, which makes reference to current international best practice guidance and other supporting documentation, will be implemented throughout the duration of the Yaoure project, ensuring that dust and particulate emissions are kept to a minimum. Typical good practice methods and dust mitigation that will be implemented, where appropriate, to control dust and PM_{10} generation during the onsite construction and operation works include the following:

- Vehicles carrying loose materials to be sheeted if dust emissions become a problem;

- Potentially dust generating material on the exterior of vehicles leaving the site to be minimised where possible;
- Use of water to suppress emissions from haul routes;
- Implementation of design controls for equipment and vehicles and use of appropriately designed vehicles for materials handling;
- Effective cladding of the berms and soil stockpiles/heaps with vegetation or large rock fragments, and the minimising of the height of storage facilities to 5 m wherever possible;
- Completed long-term stockpiles to be covered or seeded as soon as is practicable in order to stabilise surfaces (finished platforms would be covered, external slopes would be seeded and therefore eventually vegetated);
- Ensuring that all construction plant and equipment are maintained in good working order and not left running when not in use; and
- Regulating on-site movements to keep dust generating activities to a minimum.

A formal system will be put in place during the works which identifies the roles and responsibilities of site staff regarding the procedures to be applied to respond to any complaints or observations which may be made relating to air quality. Site logs will be maintained, detailing all complaints or observations received and the corresponding action taken including the response made to each complainant.

The extent to which dust mitigation measures will be implemented on site during the construction and operational phases will be flexible and responsive, with additional recommendations and measures introduced when required during particular activities which have significant dust generating potential, sensitive periods, or upon receipt of valid complaints relating to dust. Working practices will be systematically audited and revised where necessary in order to ensure dust impacts are mitigated to an acceptable level at the identified sensitive receptor locations.

The assessment of exhaust derived air pollutants from on-site activities has been remodeled using the mitigated emission factors as given in Table 8-29. As the dust mitigation measures would also reduce the emissions of the PM_{10} and $PM_{2.5}$ fractions of emitted fugitive dust, the re-modelling of emissions has focused upon PM only – all other pollutants would remain unaffected and the modelled concentrations would be the same as in the unmitigated case.

Table 8-34 shows the revised, post-mitigation results for PM_{10} concentrations expected to arise at the closest sensitive receptor to the mine site operations.

Table 8-34 Summary Maximum Revised Results for PM, post-mitigation

Pollutant	Averaging period	Air Quality Guideline (AQG) (µg/m³)	Back-ground conc. (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / AQG (%)	PEC / AQG (%)
PM_{10}	Annual mean	20	18.3	8.1	**26.4**	40.6%	**132.1%**
	Maximum 24 hour mean	50	36.6	**783.6**	**820.2**	**1567.3%**	**1640.5%**
	90.41 percentile 24 hour mean	50	36.6	11.4	48.0	22.8%	96.0%
$PM_{2.5}$	Annual mean	10	8.1	1.2	9.3	11.8%	92.8%
	Maximum 24 hour Mean	25	16.2	**123.8**	**140.0**	**495.2%**	**560.0%**

In comparison to the unmitigated case, PM_{10} concentrations from the Yaoure Project are reduced from 9.9 µg/m³ and 974.8 µg/m³, for the annual mean and maximum 24-hour mean, respectively, to 8.1 and 783.6 µg/m³, a reduction of around 18% from the unmitigated case. With these mitigation measures, it is not predicted that the EU AQS for 24 hour mean PM_{10} would be exceeded.

Table 8-35 contains the revised, post-mitigation dust deposition results for the mitigated emissions case at the most affected receptor.

Table 8-35 Maximum Predicted Dust Deposition at Sensitive Receptors, post-mitigation

Pollutant	Averaging period	Deposition criterion ($mg/m_2/day$)	PC ($mg/m^2/day$)	PC / AQG (%)
TSP	Total daily deposition	250	18.3	7.3%

Application of the mitigation measures for dust control reduces the contribution of mining activity to deposited dust levels to 18.3 $mg/m^2/day$ from 22.4 $mg/m^2/day$, representing a reduction of 18% in the forecast impact.

8.7.3.2 Significance of Impacts after Mitigation

Full implementation of best practice methods and mitigation measures to help minimise the emission and transport of dust and particulates beyond the site over the full duration of the Yaoure Project are considered to reduce the potential impact, thereby resulting in post-mitigation residual air quality impacts of Low significance.

8.7.4 Climate and Greenhouse Gases

8.7.4.1 Emission of GHG

Under IFC PS 3, impacts on climate shall be considered. Impact on climate is associated with greenhouse gas emissions. According to Point 8 of IFC PS 3,

> "For Projects that are expected to or currently produce more than 25,000 tonnes of CO2-equivalent annually, the client will quantify direct emissions from the facilities owned or controlled within the physical Project boundary [...]. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognised methodologies and good practice."

Guidance Note GN19 of PS 3 encourages disclosure their GHG emissions annually through corporate reports, or through other voluntary disclosure mechanisms currently being used by private sector companies internationally.

Greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are produced during fuel combustion in diesel engines. Formation of other greenhouse gases, such as carbon monoxide (CO), methane (CH_4) and nitrogen oxide (N_2O) will also take place which have also a significant impact on the global warming potential (GWP) of a Project, expressed by the CO_2 equivalence factors for CH_4 equal to 21 and for N_2O equal to 310 (World Bank 1998).

Nearly all of the fuel carbon is converted to CO_2 during the combustion process. This conversion is relatively independent of the firing configuration. CO_2 emissions from diesel engines are estimated with reference to the Intergovernmental Panel on Climate Change

(IPCC) Guideline (IPCC 2006). It requires that an oxidation factor be applied to the carbon content to account for a small portion of the fuel that is not oxidised into CO_2. For all oil and oil products, the oxidation factor used is 0.99 (99 percent of the carbon in the fuel is eventually oxidised, while 1 percent remains un-oxidised). To calculate the CO_2 emissions from burning diesel or similar fuel, the carbon emissions are multiplied by the ratio of the molecular weight (MW) of CO_2 (MW = 44) to the molecular weight of carbon (MW = 12): 44/12. Therefore, the equation for calculating equivalent CO_2 emissions (E) is defined as E = 2.6 kg per litre of fuel.

The diesel generators will consume approximately 1750 m^3 of diesel per month, or 21,000 m^3 per annum. The CO_{2eq} emissions are therefore approximately 55,000 tonnes of CO_{2eq} per year. This is small compared to the total GHG emissions of Côte d'Ivoire of approximately 60 Mt/a (Word Resources Institute, 2015) CO_2 equivalent, and only a very small proportion of the total emissions arising from the entire Sub-Saharan African region.

8.7.4.2 Loss of GHG Absorption Capacity

Forests play a major role in the global carbon cycle by absorbing carbon from the atmosphere through photosynthesis, storing the carbon in the form of biomass (trunks, branches, foliage, roots etc.) and as soils, whilst also emitting carbon back into the atmosphere during plant respiration and decomposition. The measure of the absorption of carbon from the atmosphere minus the overall loss of carbon through various processes is defined as the Net Ecosystem Productivity (NEP).

By approximating the area of land which will be required for the proposed infrastructure of the Yaoure Project, including reasonable estimates of probable buffers surrounding the different components, it can be estimated that the Project construction will require the removal of approximately 667 ha of vegetation as identified in the Land-Use Baseline Study (Section 6.5.2 and **Error! Reference source not found.**).

Measurements indicate NEP ranges from approximately 2 to 5 t C/(ha a) for dense, moist rain forest (Fan et al., 1990; Malhi et al., 1998, 1999). Assuming that the natural habitat to be removed at Yaoure is broadly analogous to this type of vegetation, and that grassland and forest may be assumed to have similar absorption rates per annum and hectar on an order of magnitude basis (Australian Government, 2009), it can be estimated that this removal will result in a loss in GHG absorption capacity of approximately 1,300 to 3,300 t C per year, or approximately 4,800 to 12,000 t CO_2 per year.

The reduction in GHG absorption capacity is small compared to the additional GHG emissions of the Project quantified in Section 8.7.4.1.

8.7.5 Summary of air quality impacts

See table overleaf.

Table 8-36 Summary of air quality impacts

Life cycle stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO	Construction combustion and fugitive dust/particulate emissions	Increased pollutant concentrations and dust deposition at representative receptor areas	2	1	2	Low (Negligible)
OP	Operation combustion and fugitive dust/particulate emissions	Increased pollutant concentrations and dust deposition at representative receptor areas	2	1	2	Low (Negligible)
CL	Combustion and fugitive dust/particulate emissions during closure and rehabilitation works	Increased pollutant concentrations and dust deposition at representative receptor areas	2	1	2	Low (Negligible)

* CO: Construction, OP: Operation, CL: Closure

8.8 Noise and Vibration

8.8.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

8.8.1.1 General

Noise

Noise is defined by the World Health Organisation (WHO) as 'unwanted sound'. Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities. The effects of noise can therefore be an important consideration in the environmental management of mines, and particularly in respect of surface mining schemes, where sometimes large-scale plant can be deployed. Whilst it is acknowledged that the definitive project design has not yet been 100% finalised and thus accurate predictions of future noise levels are not yet possible, this section describes predictions of possible future noise levels based upon the currently available data. Noise from the proposed gold mining operations and related processing activities associated with the project are considered. In addition, significant activities during the construction and decommissioning and closure phases have been considered including the construction of dam walls for the Tailings Management Facility (TSF).

This section also describes the good practice measures that will be implemented during the various activities making up the scheme in order to reduce potential noise effects. The noise level predictions that have been undertaken are based upon worst-case assumptions and include where applicable barrier attenuations from, e.g., excavation voids or local topography. The operational noise predictions have utilised Amec Foster Wheeler's proprietary noise modelling software, CadnaA, which uses terrain data to construct a 3D model of the area. Superimposed within this model are the noise sources making up the particular activities under consideration. The noise assessment uses these predicted noise levels, (along with information on the duration of the various activities) to describe the possible noise effects associated with the proposals. The assessment then compares noise levels that have been predicted to noise limits specified by the relevant guidance to determine whether any adverse effects are likely to occur.

Noise standards are set out in CIAPOL Decree No. 01164 of 4th November 2008 as described in Section 2.3.5. The area around the Yaoure Project can be described as encompassing either "residential or rural areas with low road traffic, traffic on waterways or air traffic" (e.g., Allahou Port – the fishing hamlet); "urban residential areas" (e.g., Akakro, Kouakougnanou and Kossou) and "urban residential areas, with some workshops or business use, or with certain degree of road/waterway/air traffic, and in the rural communities" (e.g., Allahou-Bazi and Angovia). Therefore the guidance in Table 8-37 would apply:

Table 8-37 Noise criteria applicable to Yaoure Project (in dB, from CIAPOL Decree No. 01164)

Receptors	Time		
	Day (0700 – 1800 hrs)	Intermediate period (1800 – 2200 hrs)	Night (2200 – 0700 hrs)
Allahou Port (Fishing Hamlet)	45	40	35
Akakro, Kouakougnanou and Kossou	50	45	40
Allahou-Bazi and Angovia	60	55	45

In addition, the guidance contained within the General Environmental Health and Safety (EHS) Guidelines published by the IFC (April 2007), which are technical reference documents with general and industry specific examples of international good practice, are also pertinent to this study. Reference to these guidelines forms part of the IFC's environmental and social review procedure and is compulsory for IFC clients. The EHS Guidelines are therefore considered to provide a useful resource which details the performance levels and environmental management measures which are considered achievable by existing technology and at reasonable costs.

The general EHS guidelines set out Noise Level Guidelines as detailed in Table 8-38 below, which are based on the WHO Guidelines for Community Noise. In general, noise levels should not exceed these values, or result in a maximum increase in background levels of 3 dB at the nearest receptor location. The guidelines also allow for an alternative approach, stating that where appropriate baseline data exists, describing the existing noise levels in the area, noise level limits can be represented by the baseline background or ambient noise levels.

The EHS guidelines also present examples of noise reduction options that should be considered where noise levels exceed these guideline values, along with recommendations for noise monitoring to be carried out either to establish existing ambient noise levels or to verify operational noise levels.

Table 8-38 IFC Noise Level Guidelines (in dB)

Receptor	Daytime 07:00-22:00 hrs ($L_{Aeq\ 1hr}$)	Night-time 22:00-07:00 hrs ($L_{Aeq\ 1hr}$)
Residential; institutional; educational.	55	45
Industrial; commercial	70	70

The Mining EHS guidelines of the IFC (see Section 2.8.3) recommend that noise management strategies should be employed to ensure that the General EHS Noise Level Guidelines be met.

In the UK, the 2014 amendment to BS5228-1:2009+A1:2014 *'Code of practice for noise and vibration control on construction and open sites'*, is used as the basis of predictive modelling for noise from surface mineral workings and has also been adopted by many other countries. In Amec Foster Wheeler's experience, it is widely acknowledged that the use of the BS5228-1:2009+A1:2014 methodology tends to result in slightly higher predicted noise levels than those generated by ISO9613-2:1996. Given that much of the proposed plant to be used by the Yaoure Project is similar to industrial plants with comparable noise emissions in the UK, the BS5228-1:2009+A1:2014 methodology has been used, with the acknowledgement that predicted noise levels are likely to be 'worst case'. The BS5228-1:2009+A1:2014 calculation algorithms in CadnaA have been used for all calculations.

Construction assessments are commonly based upon *'Method 1 – The ABC method'* of Annex E (informative) of BS5228-1:2009+A1:2014 which presents an example of the determination of significance due to construction noise by considering the change in ambient noise levels up to a stated threshold level. The appropriate threshold levels to be used are based upon the existing measured ambient noise levels (rounded to the nearest 5 dB) and the period during which construction is to take place (as shown in Table 8-39 below). Based on the baseline monitoring undertaken in February 2015 the construction noise levels appropriate to the Yaoure Project would be those within Category A in Table 8-39.

Table 8-39 Example Threshold of Potential Significant Effect at Dwellings from Annex E of BS5228:2009+A1:2014

Assessment category and threshold value period (L_{Aeq})	Threshold Value, $L_{Aeq,T}$ dB		
	Category A A)	Category B B)	Category C C)
Night-time (2300-0700)	45	50	55
Evenings and weekends D)	55	60	65
Daytime (0700-1900) and Saturdays (0700-1300)	65	70	75

A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values

B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

D) 1900-2300hrs weekdays, 1300-2300 Saturday and 0700-2300 Sundays.

Note 1. A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the Category appropriate to the ambient noise level

Note 2. If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total $L_{Aeq,T}$ noise level for the period increases by more than 3dB due to construction activity

Note 3. Applied to residential receptors only

The noise assessment has assumed that construction of the development would be undertaken on a 24 x 7 basis and therefore, derived from the baseline noise monitoring, the weekday daytime (0700-1900hrs) and Saturday (0700-1300hrs) construction noise criterion would be a minimum of 65 dB $L_{Aeq,\ T}$. The corresponding evening (19:00-23:00 hrs weekdays, 13:00-23:00 hrs Saturdays and 07:00-23:00 hrs Sundays) and night-time (23:00 – 07:00 hrs) criteria would be 55 dB and 45 dB $L_{Aeq,\ T}$, respectively.

Vibration

Due to the separation distances and the type of activities involved in the construction of the project it is not considered that construction vibration would be an issue at any of the sensitive receptors around the site. The activity that is likely to create the highest levels of construction vibration is the breaking out of the concrete rafts during the decommissioning and closure phase of the project. The shortest distance from this activity to the closest receptor (the southern fringe of Allahou-Bazi) is estimated to be in excess of 350 m. Vibration levels from breaking out activities are likely to be lower than those from piling hammers which are capable of producing levels of 1mm/s peak particle velocity (PPV) at distances of about 55 m (source "Control of Vibration and Noise During Piling", a British Steel publication). A PPV of 1 mm/s is the magnitude of vibration described by Table B.1 of BS5228-2:2009 as *"It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents"*.

At distances of about 300 m vibration levels from piling hammers are less than 0.1 mms PPV which is likely to be imperceptible to most people. For this reason, construction vibration has been scoped out of the remainder of this assessment.

However, during the operational stage the main source of vibration will be from blasting operations within the pit, hence a separate blasting vibration chapter is included as Section 8.9 of this document.

8.8.1.2 Scope of Assessment

A number of legitimate settlements have been identified in the area surrounding the Yaoure Project site and the following have been chosen as receptors (see also Section 6.9):

- Allahou-Bazi (southern fringe) – Easting 220356, Northing 778347;
- Angovia (southern fringe) – Easting 219749, Northing 777964;
- Akakro (north eastern fringe) – Easting 217897, Northing 775974;
- Allahou Port – Fishing Hamlet (south western fringe) – Easting 222395, Northing 779838;
- Kouakougnanou (northern fringe) – Easting 222612, Northing 774799;

- Kossou (western fringe) – Easting 225517, Northing 775434;
- Construction Mine Camp (western fringe) – Easting 221868, Northing 778187; and
- Operational Mine Camp (Western Fringe) – Easting 223549, 778988.

The nearest of these settlements is Allahou-Bazi/ and Angovia which are located to the north of the Yaoure Project area, approximately 570 m and 825 m, respectively, from the extraction area and about 630 m and 1170 m, respectively, from the dumping area. The nearest settlement to the south west of the site is Akakro, which is 1750 m from the extraction area. Allahou Port, the fishing hamlet, is about 2160 m to the north east of the extraction area and 2200 m from the processing plant area. To the south of the Yaoure Project the closest settlement is Kouakougnanou which is about 1935 m from the extraction area and 2860 m from the processing area. Kossou, to the south east of the mine site, is about 3960 m from the extraction area and 4160 m from the processing area. The operational mine camp is located some 2295 m from the extraction area and 1500 m from the processing plant area.

Thus, the nearest buildings on the southern fringes of Allahou-Bazi and Angovia; the western fringe of Kossou and the operational mine camp; south western fringe of Allahou Port (fishing hamlet); northern fringe of Kouakougnanou and on the north eastern fringe of Akakro have been used as representative sensitive receptor groups for this noise assessment.

8.8.1.3 Level of impact

Amec Foster Wheeler's proprietary noise modelling software, CadnaA, has been used to calculate individual noise levels at receptor locations from the operational phase of the mine site and has also been used to generate noise contours illustrating how noise levels attenuate with distance away from the main mine site (see Figure 8-8 to **Error! Reference source not found.**). The construction noise predictions have been undertaken using spreadsheet models based on the same methodologies as those incorporated within CadnaA.

The methodology detailed in BS 5228-1:2009+A1:2014 has been used for the noise prediction calculations; however, to reinforce a realistic worst case assessment only the barrier attenuations due to topography and, for example, the rim of the pit or the waste rock dumps have been used. The noise modelling process is complex, but in simple terms it involves the input of the following source data:

- Location of receptors (residential properties) and other buildings from mapping and aerial photography data;
- Existing ground contours from site survey or mapping data;

- Location of mining and processing equipment: Each item of mobile plant is a point source, but its location is not necessarily fixed during each phase. It has been assumed that at least one mobile plant team will be located at closest approach to the receptor within a particular working area. For example one waste/ore extraction team (comprising a large bulldozer and 136 t dumptruck) will be located within the mining area at closest approach to the receptor, with the remaining teams distributed around the pit area;

- Location of Haul Roads: For the waste/ore extraction activities it has been assumed that the haul roads within the pit converge on one area to climb out of the pit. This road then travels across the surface to a ramp up onto the waste rock dump (closest to the receptor) before being distributed around the top level;

- Noise Emission data: Noise emission data taken from manufacturers' information, other published sources (e.g. BS5228-1:2009+A1:2014) or direct measurements of similar equipment, is assigned to each item of plant. The assumed list of plant and associated sound power level and 'on-time' (time at full power) is presented in Table 8-40 and Table 8-41;

- Location of noise barriers – only the edge of the pit and the local topography (including the screening mound associated with WRD A) have been considered; and

- Absorption properties of intervening ground between noise source and receptor (it has been assumed that the intervening ground is predominantly acoustically soft e.g., vegetation cover). Note that where either ground or barrier attenuation occurs only a single attenuation has been taken into account, ie ground and barrier effects have not been combined - as recommended in BS5228-1:2009+A1:2014.

8.8.1.4 Assumed Plant Complement

The plant complement for the Yaoure Project is based on the information available at the time of writing. Whilst it is acknowledged that this may change as the final design is worked out, it is considered that the plant complements indicated in Table 8-40 and Table 8-41 below, are typical for the construction and operation (respectively) of this type of development:

It must be emphasised that for the utilisation of equipment assumptions had to be made due to the lack of specific information. Assumptions are either based on experience in similar mining projects or, where such experience is not available, a conservative 100% plant on-time has been assumed (denoted by a double asterisk in the tables below) that significantly overestimates the realistic on-time.

Table 8-40 Assumed Construction Plant Complement and Associated Sound Power Levels

Plant Type	Number	On-Time** (% at full power)	Assumed Sound Power Level dB(A)	Notes
Construction Phase (General in Processing Plant Area)				
Compressor	2	100	103 total	Supplying air to equipment
Generator	2	100**	105 total	Supplying temporary power
Concrete mixer discharging	2	100	105 total	General construction activities
Scaffolding	N/A	83	100	General construction activities
Blockwork erection	N/A	100	75	General construction activities
Road Lorry delivering materials	N/A	50	108	Delivery of materials
Excavator	1	83	104	Site preparation
Site dumper	1	83	106	Haulage of materials
Site forklift	1	83	104	General construction activities
Mobile crane	1	83	109	General construction activities
Construction Phase (concrete raft construction at Processing Plant, Mine Camp and Stock Pile Areas)				
Lorry Mounted mixer discharging	2	83	110 total	Each Concreting operations
Vibrating poker	2	50	102 total	Each Concreting operations
Concrete scabbler	2	50	114 total	Concreting operations
Knocking out shuttering	2	83	105 total	Concreting operations
Construction Phase (borrow pit activities & dam wall construction for TSF)				
Large Excavator	1	83	109	Extracting material
20t road lorry	3 x 4 trips/hour	67	105*	Hauling material
Small excavator	1	83	104	Place material
Bulldozer & vibrating roller	1	83	115	Construct dam walls
Closure Phase (demolition of concrete rafts)				
Excavator with hydraulic hammer attachment	1	83	118	Breaking concrete rafts
Excavator	1	83	104	Loading out waste materials
Road Lorry	1	50	108*	Hauling waste materials
Site Dumper	1	83	106	Hauling of materials

* Based on an L_{Amax} level from a drive by, as required by BS5228-1:2009+A1:2014.

Table 8-41 Operational Plant Complement and Associated Sound Power Levels

Plant Type	Number	On-Time** (% at full power)	Assumed Sound Power Level dB(A)	Notes
Waste & Ore Extraction				
CAT 6040E excavator (or similar)	4	83	113 each	Excavating waste rock and ore
CAT 785 dumptruck (or similar)	34 x 2-3 trips/hr	50 (WRD) & 20 (direct tipping into crusher)	120 each	Hauling waste to dump on Waste Rock Dump (24) and ore to processing plant reception grizzly (10)
Komatsu PC 850 excavator (or similar)	1	83	108 each	Excavating waste rock and ore
Komatsu D375A-6R Bulldozer (or similar)	4	50	113 each	Maintenance within pit (3 pcs.) and Waste Rock Dump (1 pcs.)
Komatsu WD600-6 wheeled dozer (or similar)	1	50	113 each	Maintenance within pit and Waste Rock Dump
Sandvik D45 Drilling Rig with NoiseGuard (or similar)	11	70	115 each	Drilling blast shot holes in pit
Sandvik DP 1500i Drilling Rig with NoiseGuard (or similar)	1	70	115 each	Drilling blast shot holes in pit
Allight Lighting Plant (or similar)	7	50	85 each	In pit (6 pcs.) and on WRD (1 pc.)
Processing Plant Area				
Primary Crusher	1	50	114	Crushing ore
CAT 992 Wheeled Loading Shovel (or similar)	2	83	116 each	Maintenance of reception area
Ball Mill and trommel screen	1	100	112	Secondary preparation of ore
SAG Mill and trommel screen	1	100	116	Secondary preparation of ore
Pre leach screening	1	100	106	Screening prior to further treatment
Pre leach thickener	1	100	88	Ore separation
Pre leach thickener pumps	2	100	95	In total
CIL Area	7	100	106	In total
CIL Tail Screen	1	100	106	
Acid Wash Pumps	4	100	98	In total
Elution Pumps	3	100	97	In total
Tailings Detox Agitator + pump	3	100**	103	In total
Tailings Pumps	2	100	98	In total
Process Water Pumps	7	100	88	In total
Raw Water Pumpsf	9	100	90	In total
TSF Dam water return pump	2	100**	95	In total
1 MW backup diesel generator (eg 1 No. Aggreko 1000kVA containerised generator or similar)	1	100**	98	In processing area

8.8.1.5 Results of Noise Predictions

Construction Phase

The removal and storage of soils will not be any noisier than the predictions for the *"the total for all construction activities"*. The levels of noise predicted during the construction phase for the sensitive receptors discussed in section 8.8.1.2 above are tabulated in Table 8-42 below:

Table 8-42 Calculated Noise Levels for Construction Phase (dB $L_{Aeq, 1h}$)

Receptor Location	Construction Phase			
	General Construction Activities (Processing Plant Area)	Concrete Raft Construction (Processing Plant Area, Mine Camp or Stocking Area)	TSF dam construction	Total for all Construction Activities
Allahou-Bazi	44.0	43.0	34.8	**46.9**
Angovia	39.0	38.4	36.0	**42.8**
Akakro	28.5	28.0	33.2	**35.3**
Allahou Port (Fishing Hamlet)	37.3	36.7	28.9	**40.3**
Kouakougnanou	31.5	31.0	37.8	**39.4**
Kossou	28.1	27.6	28.7	**32.9**
Construction Camp	64.8	63.8	34.1	**67.3**

Table 8-42 indicates that, with the exception of the construction camp itself, noise levels generated by the construction phase of the Yaoure Project are all well within the 65 dB $L_{Aeq, T}$ daytime criterion derived from Annex E of BS5228-1:2009+A1:2014 as set out in Table 8-39 above. Indeed, noise levels generated by the construction phase of the Yaoure Project are all well within the 55 dB $L_{Aeq, 1h}$ criterion stipulated in the IFC EHS Noise Level Guidelines set out in Table 8-38 above. Even if the individual construction operations were to be undertaken on a 24 hour basis then the night-time criterion of 45 dB $L_{Aeq, T}$ would not be exceeded at the majority of receptors. At Allahou-Bazi the night-time criterion from BS5228:2009+A1:2014 could be potentially exceeded by about 2 dB(A) only if all three construction activities were to be undertaken simultaneously. Due to the worst case nature of the prediction methodology it is considered that some additional mitigation may therefore be necessary if all three construction activities are likely to be undertaken simultaneously at night.

It is considered that the construction camp itself cannot be considered to be a normal noise sensitive receptor like the other locations around the mine site. This is because the occupants of the construction camp will be aware of the activities being undertaken on the site and that the occupants of the camp will have a vested interest in the construction activities being undertaken as efficiently as possible and are therefore less likely to complain about noise. However, some additional screening, e.g., in the form of earth mounds around the construction camp perimeter, may need to be considered to provide additional screening to the occupants particularly if nightshift workers are trying to sleep during the daytime period.

Therefore, for the construction phase a magnitude of impact of “Minor” has been assigned to all the receptors and when this is combined with the receptor sensitivity of “Medium” it is concluded that the environmental noise impact category would be “Low” (as defined in Section 7.2).

Operational Phase

The levels of noise predicted during the operational phase for the sensitive receptors discussed in Section 8.8.1.2 above are tabulated in Table 8-43 below and the noise contour map appears as Figure 8-8:

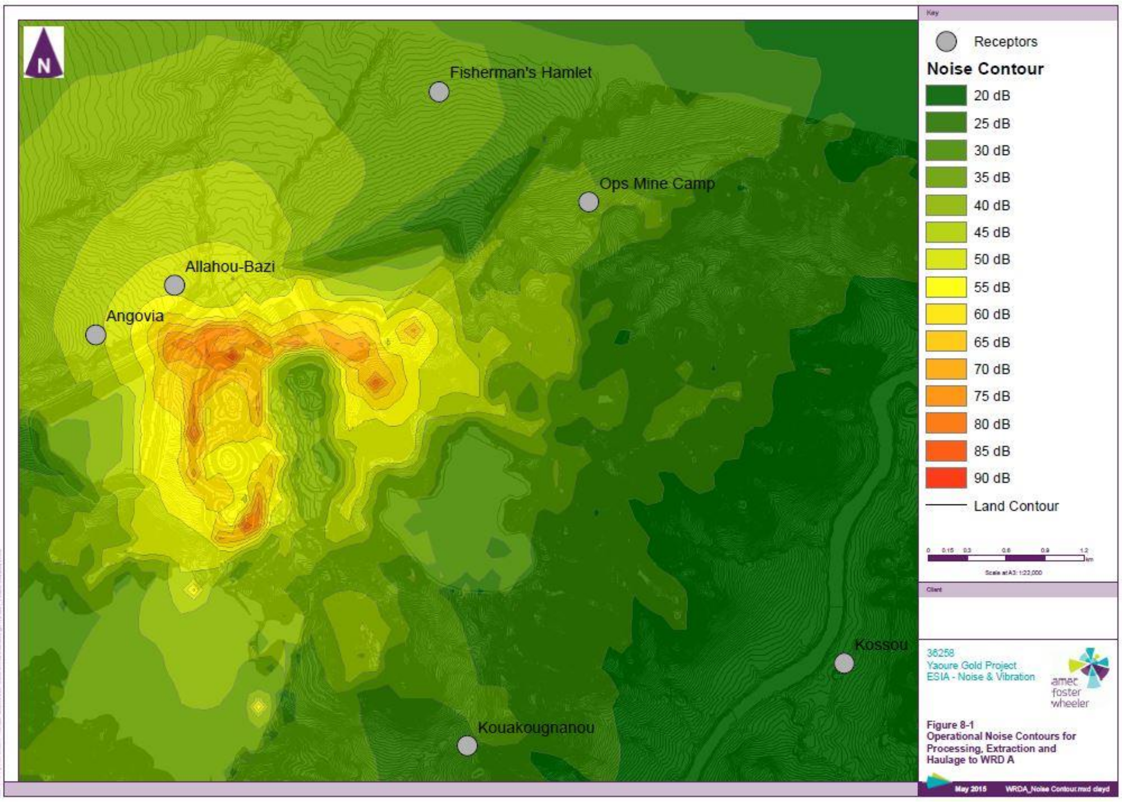
Table 8-43 Calculated Noise Levels for Operational Phase (dB $L_{Aeq, 1h}$)

Receptor Location		**Operational Phase***		
		Total extraction activities including on site haulage	Total Processing Plant activities	Total Mining activities
Allahou-Bazi	Haulage to Waste Rock Dump	53.0 (44.0**)	31.0 (31.0**)	**53.0 (44.0**)**
Angovia	Haulage to Waste Rock Dump	49.0 (40.0**)	27.0 (27.0**)	**49.0 (41.0**)**
Akakro	Haulage to Waste Rock Dump	28.0 (28.0**)	20.0 (20.0**)	**29.0 (29.0**)**
Allahou Port (Fishing Hamlet)	Haulage to Waste Rock Dump	37.0 (35.0**)	17.0 (17.0**)	**37.0 (35.0**)**
Kouakougnanou	Haulage to Waste Rock Dump	29.0 (29.0**)	17.0 (17.0**)	**29.0 (29.0**)**
Kossou	Haulage to Waste Rock Dump	22.0 (22.0**)	12.0 (12.0**)	**22.0 (22.0**)**
Operational Mine Camp	Haulage to Waste Rock Dump	28.0 (28.0**)	35.0 (35.0**)	**36.0 (36.0**)**

* Plant operating uscreened on the upper edge of the waste rock dump

** Figures in parentheses () for plant operating behind a 5m high outer bund on the upper edge of the waste rock dump

Figure 8-8 Operational Noise Contours for processing, extraction and haulage to WRD



Noise levels generated by the operational mining phase of the Yaoure Project are indicated in Table 8-43 above. This table shows the results of calculations undertaken in CadnaA and includes the extraction of both ore and waste rock, the processing activities for ore and the haulage and disposal of waste in waste rock dumps WRD A, B and C, respectively. The table also includes the disposal of tailings within the TSF area (main noise source assumed to be clean water return pump). The initial modelling assumed that a truck team and associated bulldozer worked unscreened on the upper edge of the closest waste rock dump to the receptor location, with the plant being placed as close as practically possible to the closest receptor(s) in order to reinforce a worst case assessment. In some cases it was found that this worst case assessment exceeded the CIAPOL daytime, evening or night-time criteria for a receptor(s). However, it is envisaged that the waste rock dumps will be constructed in a series of individual areas and lifts and that each area/lift will be approximately 5-10 m high. The predicted noise levels in parentheses in Table 8-43 assume that the outer edge of the dump has already been constructed and that plant (including dumptruck(s), bulldozer, and lighting rig(s)) is operating behind a 5 m high outer screen. This effectively reduces noise levels to receptors out with the mine site boundary from these sources.

From examination of the results in Table 8-43 and assessment against the criteria within Table 8-37 the following is evident:

Waste Rock Dump (WRD)

When plant is operating on the outer edges of the WRD, calculated noise levels for the total mining activities are all well within the criteria for all receptors during the daytime and evening periods. They are also without exception all below the 55 dB $L_{Aeq, 1h}$ daytime criterion stipulated in the IFC EHS Noise Level Guidelines set out in Table 8-38 above. However, if activities were expected to occur 24hr/24 and 7 day/7 with night-time tipping activities were to be considered then the night-time noise criteria from Table 8-37 would be exceeded at Allahou-Bazi, Angovia and Allahou Port (Fishing Hamlet).

However, the modelled noise levels for screened tipping operations on WRD indicate that night-time activities would comply with the CIAPOL criteria in Table 8-37. In addition, all the calculated noise levels from screened tipping operations on WRD are within the IFC EHS Guidelines night-time criterion of 45 dB $L_{Aeq, 1h}$.

With the above mitigation measure implemented, during extraction operations a magnitude of impact of "Minor" has been assigned to all the receptors and when this is combined with the receptor sensitivity of "medium" it is concluded that the environmental noise impact category would be "Low" (as defined in Section **7.2**).

Decommissioning and Closure Phase

The levels of noise predicted during the decommissioning and closure phase for the sensitive receptors discussed in Section 8.8.1.2 above are tabulated in Table 8-44 below:

Table 8-44 Calculated Noise Levels for Decommissioning and Closure Phase (dB $L_{Aeq, 1h}$)

Receptor Location	**Closure Phase**
	Breaking Out Concrete Rafts in Processing Plant Area
Allahou-Bazi	47.7
Angovia	42.7
Akakro	32.0
Allahou Port (Fishing Hamlet)	40.9
Kouakougnanou	35.1
Kossou	31.7
Operational Mine Camp	40.2

Noise levels generated by the most significant activity during the decommissioning and closure phase of the Yaoure Project are indicated in Table 8-44 above. The noise levels are associated with the breakout of the concrete pads and rafts using an excavator mounted hydraulic hammer (colloquially known as a "pecker"). The table shows the results of calculations assuming that the concrete breakout activities are at their closest separation distance to each receptor. Table 8-44 indicates that noise levels generated by the decommissioning and closure phase of Yaoure Project are all well within the 65 dB $L_{Aeq,\ 1h}$ criterion stipulated in Annex E of BS5228-1:2009+A1:2014. Indeed, the results are all well within the 55 dB $L_{Aeq,\ 1h}$ criterion stipulated in the IFC EHS Noise Level Guidelines.

With the exception of the Allahou-Bazi receptor(s), based on these predicted noise levels concrete break out activities could even be undertaken during the night-time period, if required, subject to the requirements of any H&S policy regarding this type of activity. If concrete break out operations are to be considered close to Allahou-Bazi then some additional temporary screening would be required to reduce noise levels to below 45 dB $L_{Aeq,\ 1h}$ at these receptors.

With the screening in place for night-time break out activities near Allahou-Bazi, then during decommissioning and closure activities a magnitude of impact of “Minor” has been assigned to all the receptors and when this is combined with the receptor sensitivity of “Medium” it is concluded that the environmental noise impact category would be “Low” (as defined in Section 7.2).

8.8.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

8.8.2.1 Construction, Decommissioning and Closure Phases

A further reduction in the potential noise impact (albeit already rated “Low”) could be achieved by the following, which can be characterised as “good practice to minimise noise disturbance at receptors”:

- Adopting a sequential approach to the construction of pit dump, involving the construction of an outer face behind which more unloading / loading could proceed. This is particularly important for dumping construction during night-time for local community receptors;
- If nocturnal offloading activities are required, noise monitoring is performed to determine compliance with CIAPOL requirements;
- Use of plant fitted with effective exhaust silencers and noise insulation;
- All plant will be operated, wherever possible, to meet the requirements of the IFC EHS Environmental Noise Guidelines. In addition, workers on the site will have to comply with the required IFC EHS personal noise dose levels, ensuring that an element of noise mitigation would have to be “designed in” initially.
- Use of SMART reversing alarms where practicable to reduce the effects of reversing bleepers on site vehicles;
- All plant to be regularly serviced, maintained and operated in accordance with the manufacturer’s instructions. Machines that are intermittently used will be shut down in the intervening periods between work or throttled down to a minimum;

- All construction activity to be undertaken in accordance with the good practice as described in BS5228-1:2009+A1:2014 (see also Noise and Vibration Management and Monitoring Plan – **Error! Reference source not found.**);
- Local communities to be kept informed of general site activities, including working hours. A good example of this will be during stages of the construction phase where plant is operating very close to the site boundary;
- As far as possible, the noisiest construction activities will be limited to a quarter of a day without the agreement of the appropriate supervisory organism;
- There will be adequate planning in place to ensure that lengthy operations, e.g., concrete pours, can be completed within the agreed working hours;
- All reasonable steps will be taken to limit the amount of delivery vehicles queuing or waiting to deliver to the site;
- All activities in close proximity to the site boundary will be undertaken as quickly and efficiently as possible;
- With the exception of acoustically enclosed generators, pumps and electric plant, all static plant will be shut down when not in use;
- Regular monitoring of noise levels at selected sensitive receptors, with additional monitoring undertaken during particular activities considered likely to generate elevated noise levels; and
- Appointment of an onsite contact to whom complaints/queries about construction activities can be directed. Any complaints to be investigated and action taken where appropriate.

8.8.2.2 Operational phase

In addition to the measures described above for construction noise reduction (which is equally applicable to operational noise) operational noise impacts (albeit already rated “Low”) could be further reduced by:

- If deemed necessary, the use of temporary noise barriers around particularly noisy plant and equipment (with any cooling requirements given careful consideration), particularly on the edges of the waste rock dumps (see above);
- The ore reception area be designed and operated in order to reduce the drop heights of materials wherever possible; and
- Regular monitoring of noise levels at selected sensitive receptors, with additional monitoring undertaken during particular activities considered likely to generate elevated noise levels;

The Mining EHS Guidance of the IFC (2007) also provides examples of noise control techniques particularly relevant to mining projects including the following that will be applied as appropriate:

- Implementation of enclosure and cladding of any processing plants;
- Installation of proper sound barriers and/or noise containments, with enclosures and curtains at or near the source equipment (e.g. crushers, grinders, and screens);
- Installation of natural barriers at facility boundaries, such as vegetation curtains or soil berms; and
- Optimisation of internal- traffic routing, particularly to minimise vehicle reversing needs (reducing noise from reversing alarm) and to maximise distances to the closest sensitive receptors.

8.8.3 Post-mitigation impacts

In the long term over the entire life of the site, i.e., operation and into closure, and if implemented correctly the mitigation measures described in Sections 8.8.2.1 and 0 above will reduce the potential noise impact of the development to a significance of Low.

8.8.4 Summary of noise and construction vibration impacts

See table overleaf.

Table 8-45 Summary of noise and construction vibration impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO	Construction noise	Noise at representative receptor areas, mainly during night time	2	1	2	Low (Negligible)
OP	Operation noise	Noise at representative receptor areas, mainly during night time	2	1	2	Low (Negligible)
CL	Noise from closure and rehabilitation works	Noise at representative receptor areas, mainly during night time	2	1	2	Low (Negligible)

* CO: Construction, OP: Operation, CL: Closure

8.9 Blasting Vibrations

8.9.1.1 General

As far as Amec Foster Wheeler is aware, there are no specific Cote d'Ivoire vibration criteria available to use for this assessment.

The International Finance Corporation of the World Bank Group have published Environmental Health and Safety (EHS) Guidelines (April 2007) which are technical reference documents with general and industry specific examples of international good practice. Reference to these guidelines forms part of the IFC's environmental and social review procedure and is compulsory for IFC clients. The EHS Guidelines are considered to provide a useful resource which details the performance levels and environmental management measures which are considered achievable by existing technology and at reasonable costs.

The industry specific EHS guidelines for mining recommend that vibration management strategies should be employed to ensure that the vibration generated from blasting operations is minimised at all times.

Ground Vibration

Potentially significant effects can arise from blasting operations in terms of ground vibration (and sometimes air overpressure) and in rare circumstances these effects can result in damage to property. International and UK Government sponsored research (Department of Transport, 1986) has led to industry agreement in respect of the levels of vibration that are likely to lead to structural damage and this in turn has led to advice in respect of the setting of vibration limits that can be enforced by the respective Regulatory Bodies. The research has also resulted in three definitions of damage that could theoretically occur at residential-type structures. These are summarised as follows:

- *'Cosmetic damage'* is the first threshold of damage and this is defined as the formation or development of existing cracks in plaster, drywall surfaces or mortar joints;
- *'Minor damage'* is defined as the formation of larger cracks or the loosening/falling of plaster etc; and
- *'Major or Structural damage'* would occur when the key structural elements of a building are damaged.

Detailed research from the United States undertaken in the 1970-1980's (Siskind et al., 1980) determined that vibration levels would need to exceed PPV levels of 50 mm/s to produce cosmetic damage to residential type structures. However, in relatively unusual circumstances (low seismic wave frequencies) cosmetic damage could occur at lower levels and typically limits based on 12.7 mm/s have been set to deal with such situations. On the other hand, this level is generally seen as quite conservative and UK based research, for example, has not identified any evidence of where cosmetic damage has occurred below these levels.

The Australian and New Zealand Environment Council published guidelines in 1990 (Australian and New Zealand Environment and Conservation Council, 1990) in which ground vibration from blasting operations are often restricted to 5 mm/s for 95% of blasts measured in a 12 month period, with no individual blast exceeding 10mm/s at any time.

Another factor to take account of in the assessment is human perception to vibration levels and this is because generally people will become aware of vibration at levels of around 1.5 mm/s and occasionally at levels as low as 0.5 mm/s. Depending on the individual person, vibration perception can therefore lead to the generation of complaints, even at very safe levels of vibration. Operators may therefore take this factor into account when designing blasts to minimise the risk of complaints, but such an approach does not need to be reinforced by the setting of lower vibration limits by regulatory bodies.

For example, this is recognised in UK minerals guidance including BS 6472-2:2008 *"Guide to the evaluation of human exposure to vibration in buildings; Part 2: Blast-induced vibration"* which indicates in section 6, entitled Satisfactory Vibration Magnitudes, that *"for blast vibration occurring up to three times per day the generally accepted maximum satisfactory magnitude for residential premises is a PPV* (peak particle velocity) *of 6.0 mm/s"*. However, it does also state that vibration magnitudes between 6.0 – 10.0 mm/s could be used if 6.0 mm/s is considered to be too restrictive. It is common practice in the UK and other countries to apply a confidence limit to any blasting criteria, for example, a common blasting criterion in the UK is 6 mm/s at 95% confidence limit over a stated time period. This effectively means that only 1 in 20 blasts, measured over say the course of one year, will statistically exceed the 6 mm/s limit. However, again because of the statistical analysis involved, this ensures that the absolute maximum PPV would never exceed about 12 mm/s.

With respect to this assessment, it is considered that exceedance of a PPV of 6 mm/s for 95% of all blasts within any six month period (with a maximum level of 12 mm/s) at any of the residential properties located in the vicinity of Yaoure Project would normally be considered to represent significant vibration effects. This is based on advice contained within recent British Standards (BS 6472-2:2008) rather than on advice first published in 1990 in Australia and New Zealand. As for the potential effects on major services, which are much less sensitive to vibration, significant effects would only occur if a level of 50 mm/s at a 99.9% confidence were exceeded.

Air Overpressure

Comprehensive investigations into the nature and effects of air overpressure with particular reference to its damage potential have also been undertaken by the USBM

(Siskind et al., 1980), which has reviewed the relevant other published data on this subject. The research has concluded that the weakest parts of most structures that are exposed to air overpressure are windows. In particular, poorly mounted, and hence pre-stressed windows, might crack at ~150 dB (0.1 psi) with most cracking at 170 dB (1.0 psi). Structural damage can be expected at 180 dB (3.0 psi).

With respect to determining what constitutes significant effects in terms of air overpressure, specific levels have not been identified in the relevant UK Government and other International guidance. This is mainly to do with the influence of weather conditions (very variable in the UK and indeed in Cote d'Ivoire which has distinct rainy and hot seasons) on air overpressure, but also due to very high levels that would need to occur to cause structural damage.

In addition, British Standard (BS) 6472-2:2008, indicates in Section 5.3 that the prediction of air overpressure is *"almost impossible"* and goes on to state that *"control of air overpressure should always be by its minimisation at source through appropriate blast design"*.

Because of the climatic variability in Cote d'Ivoire, the fact that air overpressure levels can be adequately be controlled at source using best practice blasting techniques, and that the latest UK Government guidance determined that an air overpressure limit cannot be defined; it was considered inappropriate to carry out predictions nor define any criteria in this respect.

Possible Other Effects

The fact that the human body is very sensitive to vibration can result in subjective concern being expressed at energy levels well below the threshold of damage. People will generally become aware of blast induced vibration at levels of ~1.5 mm/s, although under some circumstances this can be as low as 0.5 mm/s. Even though such vibration is routinely generated within any property and is also entirely safe, when it is induced by blasting activities it is not unusual for such a level to give rise to subjective concern. Such concern is also frequently the result of the recent discovery by a householder of cracked plaster or brickwork that in fact has either been present for some time or has occurred due to natural processes.

Experience of surface mining and quarrying operations suggests that virtually all complaints regarding blasting arise because of the concern over the possibility of damage to owner-occupied properties. Such complaints are largely independent of the vibration level. In fact, once an individual's perception threshold is attained, complaints can result from 3-4% of the total number of blasts, irrespective of their magnitude.

8.9.1.2 Scope of Assessment

The construction, operation and de-commissioning of the proposed Yaoure Project has potential for vibration emissions, however, only the operational phase has potential to create significant levels due to the blasting activities associated with extraction of the overburden (waste) and ore body.

A number of legitimate settlements have been identified in the area surrounding the Yaoure Project site and, with the exception of the construction camp, the same receptors as those used for the noise assessment have been assessed for blasting vibration (see also Section 8.8.1.2).

All predictions of Peak Particle Velocity (PPV) have been assumed to be undertaken to the nearest dwelling to the closest blast panel in each of these receptor groups. This section also describes the good practice measures that are recommended for implementation during the blasting activities on Yaoure in order to reduce potential vibration effects.

8.9.2 Level of impact

8.9.2.1 Introduction

Ground Vibration

The accepted method of predicting peak particle velocity for any given situation is to use a scaling approach utilising separation distances and instantaneous charge weights. This method allows the derivation of the site specific relationship between ground vibration level and separation distance from a blast.

A scaled distance value for any location may be calculated as follows:

Scaled distance, SD = $DW^{-½}$ in $mkg^{-½}$

Where D = Separation Distance (Blast to Receiver) in metres

W = Maximum Instantaneous Charge in kg

i.e. maximum weight of explosives per delay in kg

For each measurement location the maximum peak particle velocity from either the longitudinal, vertical or transverse axis is plotted against its respective scaled distance value on logarithmic scales. An empirical relationship derived by the USBM relates ground vibration level to scaled distance as follows:

$PV = a (SD)^b$

Where PV = Maximum Peak Particle Velocity in mm/s

SD = Scaled Distance in $mkg^{-½}$

a, b = Dimensionless Site Factors

The dimensionless site factors (a and b) allow for the influence of local geology upon vibration attenuation as well as geometrical spreading. The values of a and b are derived for a specific site from least squares regression analysis of the logarithmic plot of peak particle velocity against scaled distance which results in the mathematical best fit straight line where:

a is the peak particle velocity intercept at unity scaled distance; and

b is the slope of the regression line.

In almost all cases, a certain amount of data scatter will be evident, and as such statistical confidence levels are also calculated and plotted.

The statistical method adopted in assessing the vibration data is that used by Lucole and Dowding (1979). The data are presented in the form of a graph showing the attenuation of ground vibration with scaled distance and results from log - normal modelling of the velocity distribution at any given scaled distance. The best fit or mean (50%) line as well as the upper 95% confidence level are plotted.

The process for calculating the best fit line is the least squares analysis method. The upper 95% confidence level is found by multiplying the mean line value by 1.645 times 10 raised to the power of the standard deviation of the data above the mean line. A log-normal distribution of vibration data will mean that the peak particle velocity at any scaled distance tends to group at lower values.

From the logarithmic plot of peak particle velocity against scaled distance, for any required vibration level it is possible to relate the maximum instantaneous charge and separation distance as follows:

Maximum Instantaneous Charge (MIC) = $(D/SD)^2$

Where D = Separation Distance (Blast to Receiver) in metres

SD = Scaled Distance in $mkg^{-½}$ corresponding to the vibration level required.

The scaled distance approach assumes that blast design remains similar between those shots used to determine the scaling relationship between vibration level and separation distance and those for which prediction is required. For prediction purposes, the scaling relationship will be most accurate when calculations are derived from similar charge weight and distance values.

The main factors in blast design that can affect the scaling relationship are the maximum instantaneous charge weight, blast ratio, free face reflection, delay interval, initiation direction and blast geometry associated with burden, spacing and stemming. Although the instantaneous explosive charge weight has perhaps the greatest effect upon vibration level, it cannot be considered alone, and is connected to virtually all aspects of blast design through the parameter blast ratio.

The blast ratio is a measure of the amount of work expected per unit of explosive, measured for example in tonnes of rock per kilogram of explosive detonated (tonnes/kg), and results from virtually all aspects of a blast design i.e. hole diameter, depth, burden, spacing, loading density and initiation technique.

The scaled distance approach is also strictly valid only for the specific geology in the direction monitored. This is evident when considering the main mechanisms which contribute to ground motion dissipation:

- Damping of ground vibrations, causing lower ground vibration frequencies with increasing distance;
- Discontinuities causing reflection, refraction and diffraction;
- Internal friction causing frequency dependent attenuation, which is greater for coarser grained rocks; and
- Geometrical spreading.

In practice similar rates of vibration attenuation may occur in different directions, however, where necessary these factors should be routinely checked by monitoring, especially on sites where geology is known to alter.

Airborne Vibration

Airborne vibration waves can be considered as sound waves of a higher intensity and will therefore be transmitted through the atmosphere in a similar manner. Thus meteorological conditions such as wind speed, wind direction, temperature, humidity, cloud cover, and how these vary with altitude, can affect the level of the air overpressure value experienced at a distance from any blast.

If a blast is fired in a motionless atmosphere in which the temperature remains constant with altitude, then the air overpressure intensity will decrease purely as a function of distance. In fact, each time the distance doubles the air overpressure level will decrease by 6 dB. However, such conditions are very rare and it is more likely that a combination of the key determining factors will increase the expected intensity in some areas and decrease it in others.

As stated above, the UK's BS 6472-2:2008 indicates that the prediction of air overpressure is "almost impossible" and goes on to state that *"control of air overpressure should always be by its minimisation at source through appropriate blast design"*. Because of the climatic variability in Cote d'Ivoire, the fact that air overpressure levels can be adequately be controlled at source using best practice techniques, and that International guidance determines that an air overpressure limit cannot be defined, it is inappropriate to carry out predictions in this respect and accordingly none have been undertaken for this assessment.

8.9.3 Source, Receptors, and Significance of Potential Impacts before Mitigation

8.9.3.1 Construction phase

As far as Amec Foster Wheeler is aware there will be no blasting required during the construction phase of the project. Construction vibration was considered in Section 8.8 above.

8.9.3.2 Operation phase (Methodology)

It is envisaged that future blasting operations on the Yaoure Project will be designed around the typical parameters indicated in Table 8-46 below:

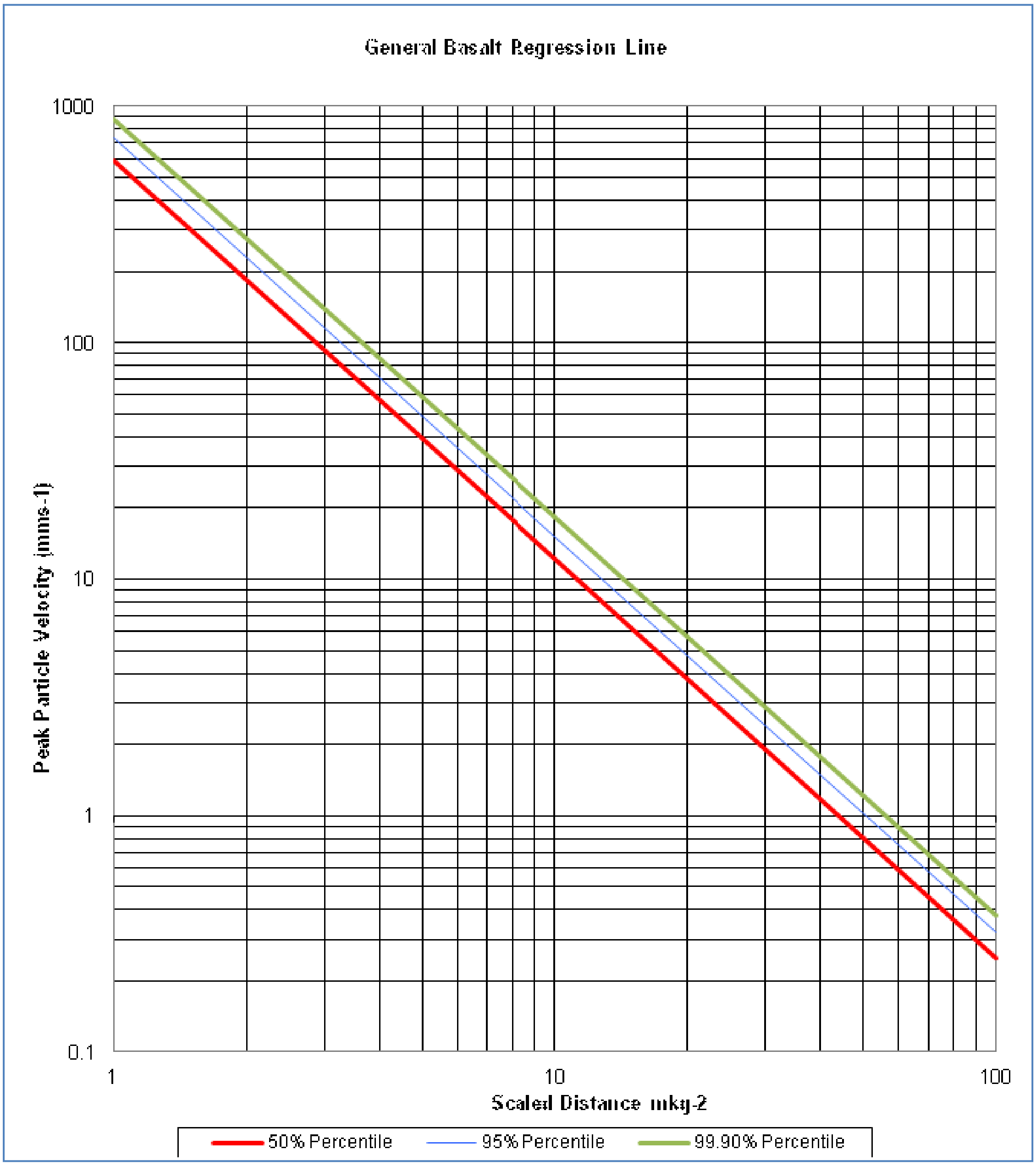
Table 8-46 Typical Blast Design Parameters on Yaoure Project

Parameter	Dry Hole Blasting	Wet Hole Blasting
Bench Height (m)	10	10
Burden x Spacings (m)	4.7-5.7 x 4.1-5.0	5.1 x 4.4
Hole Diameter (mm)	165	165
Hole Depth (m)	11.2	11.2
Sub-drill (m)	1.2	1.2
Maximum Instantaneous Charge Weight (MIC) (kg)	133.4	156.4
Type of Explosive	ANFO	Emulsion
Type of initiation	Down hole electric dets	Down hole electric dets

Thus, the typical MIC that can be used on the Yaoure Project is around 134 kg for waste/ore body extraction blasting in dry holes using ANFO and 157 kg for waste/ore body extraction blasting in wet holes using emulsion explosives.

Amec Foster Wheeler does not have any data from blasting on similar developments in Cote d'Ivoire and therefore has based this assessment on data from our database of vibration magnitudes collected on basalt quarries in the UK. Basalt is a hard rock with a density of about 2.74 t/m³ which is understood to be similar to the density of the 'fresh rock' at Yaoure which is 2.81 t/m³. The data obtained from production blasts on basalt quarries was used to generate a regression curve plot for blasting at Yaoure Project (see Figure 8-9).

Figure 8-9 Yaoure Regression Line



The use of the USBM formula to predict vibration levels calls for the maximum peak particle velocity (PPV) to be plotted against scaled distance (SD) in a logarithmic manner. The upper 95% confidence level has been taken as a basis for the interpretation given in Table 8-47 for a vibration criterion (in terms of PPV) for residential properties of 6 mm/s at 95% confidence level. In addition, Table 8-48 lists the MICs for infrastructure receptors to meet a vibration criterion of 50 mm/s PPV at a 99.9% confidence level.

Table 8-47 Maximum Instantaneous Charge Weight (MIC) related to distance, based on Vibration Limit of 6mm/s at 95% confidence level (SD = 17.364mkg$^{-0.5}$)

Blast Receiver Separation Distance (m)	MIC Waste/Ore body Extraction Blasting dry holes (kg)	Blast Receiver Separation Distance (m)	MIC Waste/Ore body Extraction Blasting wet holes (kg)
50	8.4	50	8.4
75	18.7	75	18.7
100	33.2	100	33.2
125	51.8	125	51.8
150	74.6	150	74.6
175	101.6	175	101.6
200	132.7	200	132.7
225	167.9*	225	167.9*
250	207.3*	250	207.3*
300	298.5*	300	298.5*
350	406.3*	350	406.3*
400	530.7*	400	530.7*
450	671.6*	450	671.6*
500	829.2*	500	829.2*

* In practice MICs will not exceed (an assumed) 134 kg for dry hole blasting and 157 kg for wet hole blasting due to physical constraints of each shot hole.

Table 8-48 Maximum Instantaneous Charge Weight (MIC) related to distance, based on Vibration Limit of 50mm/s at 99.9% confidence level (SD = 5.5054mkg$^{-0.5}$)

Blast Receiver Separation Distance (m)	MIC Waste Extraction Blasting (kg)	Blast Receiver Separation Distance (m)	MIC Ore Extraction Blasting (kg)
10	3.3	10	3.3
20	13.2	20	13.2
30	29.7	30	29.7
40	52.8	40	52.8
50	82.5	50	82.5
60	118.8	60	118.8
70	161.7*	70	161.7*
80	211.2*	80	211.2*
90	267.2*	90	267.2*

* In practice MICs will not exceed (an assumed) 134 kg for dry hole blasting and 157 kg for wet hole blasting due to physical constraints of each shot hole.

Closure phase

There will be no blasting required during these phases of the project and therefore blasting vibration has not been considered.

8.9.3.3 Results of Blasting Vibration Predictions

Construction phase

There will be no blasting during the construction phase of the Yaoure Project and therefore vibration from this source has not been considered in this section.

Operation phase

The closest major public utility service is the Kouakougnanou-Angovia road which runs roughly south to north and to the west of the extraction area. Whilst this road will be closed to the south of the extraction area, it will continue to be used as access to the mine area, whilst a diversion will be constructed to the south of the TSF and west of the site and WRD A to continue to provide access to the Angovia. Blasting adjacent to roadways and their associated structures and earth works is a very regular occurrence and is covered in detail within the UK's Department of Transport's Specification for Highway Works, Series 600 Earthworks, Amendment November 2009. This document recommends a resultant PPV limit of 50 mm/s for such structures and earth works during blasting operations.

The processing plant area is not considered to be vibration sensitive since processing plant on active quarries throughout the world operate without severe damage from blasting from the adjacent quarry voids.

Table 8-47 above outlines the allowable instantaneous explosive charge weight at differing separation distances to meet the proposed 6mm/s at 95% confidence level criterion for residential receptors. It indicates that a production waste/ore body blast (in dry holes) design utilising a maximum MIC weight of 134 kg, the assumed maximum anticipated on the mine for ANFO explosives, can be undertaken down to a separation distance of 201 m from any vibration sensitive residential premises whilst complying with the recommended vibration criterion. The corresponding separation distance to meet a criterion of 50mm/s at 99.9% confidence level for waste/ore body blasts (in dry holes) utilising a MIC of 134 kg is 64 m (see Table 8-48).

For waste/ore body blasting (in wet holes) with a MIC of 157kg the separation distances to meet the 6 mm/s at 95% and 50mm/s at 99.9% confidence limits are 218 m and 69 m respectively.

The predicted vibration levels at the closest residential receptors in nearby centres of population are given in Table 8-49 below. The 'mean' levels are those that the regression analysis evaluates as being most likely, whilst the 'maximum' value corresponds to the upper 95% confidence level. An assessment of the significance of the effects on the receptors, including the non-residential ones, has then been undertaken. The corresponding vibration levels at the closest infrastructure receptors are shown in Table 8-50.

Table 8-49 Worst-Case Predicted Vibration Levels at Receptors from Blasting Operations on Yaoure Project to meet 6mm/s at 95% confidence level (SD = 17.364mkg$^{-0.5}$)

Sensitive Receptor	Minimum Distance to Nearest Blasting (m)	Predicted Vibration Level for Waste/Ore Body Blasting in Dry Holes (MIC 134 kg) PPV (mm/s)		Predicted Vibration Level for Waste/Ore Body Blasting in Wet Holes (MIC 157 kg) PPV (mm/s)	
		Mean 50% Percentile	Maximum 95.0% Percentile	Mean 50% Percentile	Maximum 95.0% Percentile
Residential Receptors					
In the vicinity of Allahou-Bazi	570	0.84	1.04	0.96	1.19
In the vicinity of Angovia	825	0.45	0.56	0.51	0.64
In the vicinity of Akakro	2660	0.06	0.08	0.07	0.09
In the vicinity of Allahou Port (fishing hamlet)	2160	0.09	0.11	0.10	0.13
In the vicinity of Kouakougnanou	1935	0.11	0.13	0.12	0.15
In the vicinity of Kossou	3960	0.03	0.04	0.04	0.05

Table 8-50 Worst-Case Predicted Vibration Levels at Receptors from Blasting Operations on Yaoure Project to meet 50mm/s at 99.9% confidence level (SD = 5.5054mkg$^{-0.5}$)

Sensitive Receptor	Minimum Distance to Nearest Blasting (m)	Predicted Vibration Level for Waste/Ore Body Blasting in Dry Holes (MIC 134 kg) PPV (mm/s)		Predicted Vibration Level for Waste/Ore Body Blasting in Wet Holes (MIC 157 kg) PPV (mm/s)	
		Mean 50% Percentile	Maximum 99.9% Percentile	Mean 50% Percentile	Maximum 99.9% Percentile
Infrastructure Receptors					
New Road (Option D)	205	4.69	7.00	5.36	8.00
Existing road (to North) into Processing Plant Area	295	2.54	3.80	2,90	4.34
Existing road (to east) into Processing Plant Area	655	0.66	0.99	0.76	1.13

Examination of the data in Table 8-49 and Table 8-50 above shows that the predicted PPVs from waste/ore body blasting operations (in dry holes using MICs of 134 kg and wet holes using 157 kg, respectively) are all well within the 6 mm/s at 95% and 50 mm/s at 99.9% confidence levels for residential and infrastructure receptors, respectively.

Thus, during blasting operations a magnitude of impact of "minor" has been assigned to all the receptors and when this is combined with the highest receptor sensitivity of "medium" it is concluded that the environmental noise impact category would be "Low" (as defined in Section 7.2).

Closure phase

There will be no blasting required during these phases of the project and therefore blasting vibration has not been considered.

8.9.4 Management and Mitigation Measures and Significance of Impacts after Mitigation

A further reduction in the potential operational blasting vibration impact (albeit already rated Low) will be achieved by the following good practice measures (e.g., taken from the Operator's Good Practice Guide outlined in the UK's Department of Environment Transport and Regions (DETR) report "The Environmental Effects of Production Blasting from Surface Mineral Workings"):

- Making accurate surveys & recording of blast holes. If necessary blast design would be revised in light of survey data;
- Ensuring correct blast design including correct relationship between burden, spacing and hole diameter;
- Ensuring accurate drilling, keeping subdrill to the minimum required;
- Maximising use of free faces including by careful planning of delay sequences;
- Optimising maximum instantaneous charge weight by:
  - Reducing number of holes;
  - Reducing instantaneous charge by decking charges;
  - Reducing bench height or hole depth;
  - Reducing borehole diameter.
- Optimising blast ratio in any changes to design;
- Where practicable ensuring direction of detonation away from sensitive areas;
- Wherever possible use of unconfined charges will be avoided particularly where fissures or broken ground or weaken of rock from previous blasting is known to be present;
- Wherever possible the use of surface lines of detonating cord will be avoided. Any surface detonators and explosives will be adequately covered with suitable material;

- Stemming material will be of sufficient quality and quantity to confine adequately all explosives upon detonation. A coarse stemming material such as angular chippings will be considered. Drill fines will not be used;

- Bottom initiation will be considered in preference to top initiation;

- Misfire procedures will have due regard to under-burdened charges;

- If air overpressure is found to be a potential problem consideration will be given to reducing blast panel area;

- Blasting will be undertaken at regular times, one blast on any day and as infrequently as possible. Ground and airborne vibration levels will be monitored regularly so that information may be employed into any necessary modifications of future blast designs; and

- Appointment of an onsite contact to whom complaints/queries about operational activities can be directed. Any complaints to be investigated and action taken where appropriate.

In addition, the Mining IFC EHS Guidance states that for blasting-related emissions (e.g., vibration, airblast, overpressure, or fly rock), the following management practices are recommended:

- Mechanical ripping should be used, where possible, to avoid or minimise the use of explosives;

- Use of specific blasting plans, correct charging procedures and blasting ratios, delayed/micro delayed or electronic detonators, and specific in-situ blasting tests (the use of downhole initiation with short-delay detonators improves fragmentation and reduces ground vibrations);

- Development of blast design, including a blasting-surfaces survey, to avoid over confined charges, and a drill-hole survey to check for deviation and consequent blasting recalculations;

- Implementation of ground vibration and overpressure control with appropriate drilling grids;

- Adequately designing the foundations of primary crushers and other significant sources of vibrations.

Prior beginning of blasting, a blast test must be performed and controlled, using seismographs defined at different distances from the blasting pan, in order to collect a sufficient number of data for the creation of a regression line adapted to the Project. This regression line can then be used for future blast designs on the mine development.

8.9.5 Impacts after mitigation

In the long term over the entire life of the operation of the site, and if implemented correctly, the above mitigation measures (see Section 8.9.4) will reduce the potential blasting vibration impact of the development to a significance of Negligible.

8.9.6 Summary of blasting vibration impacts

See table overleaf.

Table 8-51 Summary of blasting vibration impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
OP	Blasting vibration	Predicted vibration levels at the closest residential receptors in nearby centres of population	2	1	2	Low (Negligible)

* CO: Construction, OP: Operation, CL: Closure

8.10 Traffic and transportation

8.10.1 Assessment Criteria

Increases in traffic as a result of new development can have a number of effects on local communities and existing road users. To the knowledge of the assessment team, there is no local guidance on methodologies for assessing potentially significant environmental effects of traffic and transportation. In the absence of this, reference has been made to the UK document, The Institute of Environmental Management and Assessment (IEMA) publication *Guidance Notes No. 1: Guidelines for the Environmental Assessment of Road Traffic* (1993), hereafter referred to as the IEMA guidelines.

The IEMA guidelines state that "…the detailed assessment of impacts is…likely to concentrate on the period during which the absolute level of an impact is at its peak, as well as the hour at which the greatest level of change is likely to occur."

As with any development there are three phases during which the proposed Project will generate levels of traffic:

- Construction;
- Operation; and
- Closure and rehabilitation.

8.10.2 Source, Receptors, and Significance of Potential Impacts before Mitigation

8.10.2.1 Potential effects

An increase in traffic as a result of a development can have a series of environmental effects on local communities, existing vulnerable road users i.e., pedestrians/two-wheelers and non-vulnerable road users i.e. cars, LGVs, HGVs.

For developments of this nature the most applicable effects to consider are summarised in the following sub-sections.

Severance

Severance is the perceived division that can occur within a community when it becomes separated by a major traffic artery and is used to describe the factors that separate people from other people and places.

The IEMA guidelines state that marginal changes in traffic flow are unlikely to create or remove severance, but that, in determining whether severance is likely to be an important issue, consideration should be given to factors such as road width, traffic flow and composition, traffic speeds, the availability of crossing facilities and the number of movements that are likely to cross the affected route. Consideration should also be given to different groups such as the elderly and young children.

Driver Delay

Delays for drivers can occur at different points on the local highway network as a result of the additional traffic that would be generated by a development. The IEMA guidelines state that delays are only likely to be significant when the traffic on the network surrounding the development is already at, or close to, the capacity of the system.

Pedestrian Delay

Changes in the volume, composition or speed of traffic may affect the ability of people to cross roads, and therefore, increases in traffic levels are likely to lead to greater delays to pedestrians. Delays would also depend upon the general level of pedestrian activity, visibility and the general physical conditions of the crossing location.

Pedestrian Amenity

Pedestrian amenity is broadly defined as the relative pleasantness of a journey, and is considered to be affected by traffic flow, traffic composition and pavement width/separation from traffic.

Fear and Intimidation

The scale of fear and intimidation experienced by pedestrians is dependent on the volume of traffic, its HGV composition, its proximity to people or the lack of protection caused by factors such as narrow pavement widths, together with factors such as the speed and size of vehicles.

Accidents and safety

Due to the numerous local causation factors involved in personal injury accidents, the IEMA guidelines do not recommend the use of thresholds to determine significance. Instead professional judgement should be applied to the assessment. If a particular accident cluster is identified, then this may also justify further analysis and the implementation of measures to mitigate effects.

Note that accidents and road safety are also specifically addressed in the Community Health, Safety and Security assessment (Sub-Section 8.13.2.2).

8.10.2.2 Traffic impacts

In order to undertake the assessment of traffic impact, information on the operation of the site has been provided by the client and is split between the principal traffic generators, namely staff travel and external deliveries. At this stage in the development appraisal process not all details are known and assumptions have been made based on professional judgment and knowledge of the local area, e.g. staff origins, traffic routing.

Staff travel

All staff employed at the mine will reside locally, with junior staff based in the surrounding villages and senior staff housed in a purpose built camp situated adjacent to the mine site. The camp will linked to the mine via a private access road, which will be constructed as part of the development proposals.

Staff travel arrangements will differ depending on grade. Senior workers are anticipated to drive to the site from the purpose built camp, whereas junior workers, residing in the surrounding local villages are more likely to walk, use a motorcycle or potentially utilise a taxi as per the observed travel arrangements currently utilised by local people.

In order to establish how the staff will travel to and from the site during the operation the existing count data was analysed to extract the distribution of travel by form of transport. Table 8-52 below shows the average modal split across the study area for pedestrians, cars and 2-wheeled transport modes based on data collected during November/December 2014 and April 2015.

Table 8-52 Modes of Travel

November/December & April Average				
	Pedestrian	**Two-Wheeler**	**Car**	**Total**
% Distribution across study area	40%	60%	-	100%

The exact origin of staff members is currently unknown, however, for the purposes of the assessment assumptions based on the intended mode of travel have been made. These assumptions are as follows:

- The proportion of staff travelling by foot will reside in the nearest settlement, Angovia. Villages further away are considered unviable due to the distances involved, the quality of the pedestrian environment and the lack of footways or street lighting.

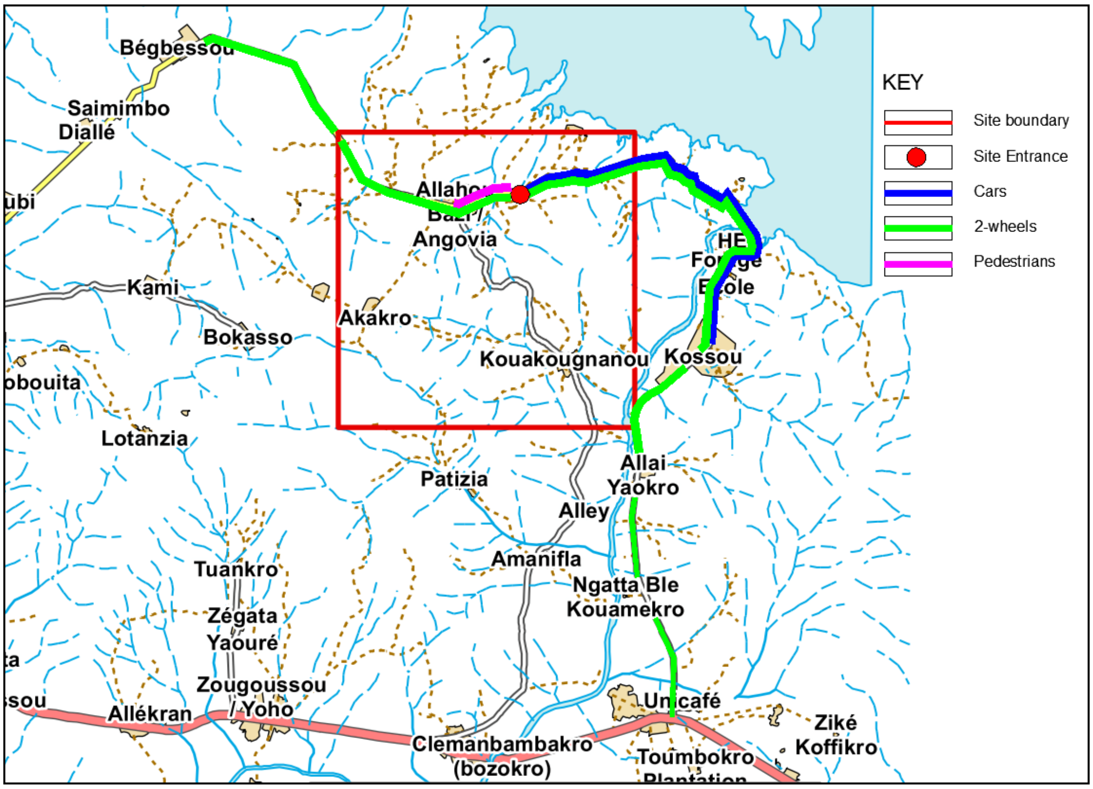
- The proportion of staff travelling by two-wheelers will be split equally between the villages of Bégbessou, Alley and Toumbokro. These villages have been selected as they represent the furthest realistic options along each of the three approaching roads.

- Whilst the use of taxis is a possibility, information on the availability of this option during the shift change over times is unknown and as such no consideration has been given.

- Currently it is planned to accommodate senior staff in a purpose built camp, close to the site entrance.

The above routes are illustrated within Figure 8-4:

Figure 8-4 Staff Travel Routes



For the purposes of assessment Perseus has provided information on the operational requirements for each of the three shifts. **Error! Not a valid bookmark self-reference.** below provides a breakdown of the workforce and likely pattern of activity for the 24 hour operation of the site.

Table 8-53 Shift Patterns and Workers (assumptions)

	Travel Movements per Shift		Pedestrian	Two-Wheeler*	Car**	Total
Mine and Plant Workers	06:00 Change Over	Arrivals	40	30	5	120
		Departures	40	30	5	120
		Total	80	60	10	240
	18:00 Change Over	Arrivals	40	30	5	120
		Departures	40	30	5	120
		Total	80	60	10	240
Administrative/ Professional Staff	07:00 Start	Arrivals	25	19	32	188
	17:00 Finish	Departures	25	19	32	188

Based on these assumptions, a detailed assessment of the additional traffic caused by the proposed Project has been carried out in **Error! Reference source not found.**. Given the context of the background flows, the actual impact is considered to be negligible due to the extremely low level of flows generated by the mine. Furthermore the absence of other traffic and other road user activity reduces the risk of interaction and thus accident potential. Given these levels of flows are currently accommodated and the anticipated mode of travel for future junior workers will be similar to existing road users it is considered that the impact of the proposed mine site in relation to staff travel will be negligible and as such no further consideration to staff travel will be given.

Furthermore, the provision of a dedicated access track between the purpose built camp and the site, minimises the level of traffic generated on the public roads, which will be of benefit to local highway safety.

Deliveries

Fuel deliveries will require approximately 90 trucks per month. As a preliminary estimate, this figure has been doubled to account for other deliveries and thus is anticipated to be approximately 180 trucks per month or nine trucks a day, assuming deliveries take place five days a week. Deliveries will either be from San Pedro or Abidjan.

Delivery frequencies may vary over the various phases of the mine's life cycle and may peak during the construction period. However, for the purpose of this ESIA, it is assumed that the deliveries will be of the same order of magnitude during the construction and operation phase.

Unlike the staff shift patterns, deliveries will not be limited to specific hours and will occur throughout the day. As such, based on a 10 hour delivery period which avoids the hour directly after sunrise and directly before sunset, deliveries could be one per hour.

Given the low frequency of expected deliveries, it is considered that the impacts on local communities will be negligible. However, measures to ensure safe working practices will be implemented.

8.10.3 Management and Mitigation Measures and Significance of Impacts after Mitigation

No specific mitigation measures are required, as the pre-mitigation impacts are already negligible. However, it will be necessary to undertake pre-operational remedial work, funded by the Government, along the principal access route in order to achieve the following:

- Reduce the likelihood of continued degradation from occurring, to the detriment of existing road users;
- Reduce the likelihood of additional expenditure on routine vehicle maintenance;

- Reduce the likelihood of spillages or accidents occurring;
- Maintain the ability to accommodate two-way traffic flows along the principal access route; and
- Attain community support by investing in local infrastructure.

Impact significance after implementing the above mitigation measures will remain negligible.

In order to ensure the assessed status of the development remains valid, the following monitoring is required:

- Traffic surveys to be conducted during cocoa harvest once every 3 years to assess whether or not any traffic growth has occurred, or whether traffic flow profiles have significantly altered;
- A review of traffic accident data along the A6, between Yamoussoukro and Bouafle;
- A review of staff movements and mode of travel to be conducted every 3 years to assess whether any significant changes may have occurred;
- A review of delivery frequencies and volumes to occur annually to ensure the assumed delivery numbers remain valid;
- A record of any traffic accidents that involve employees, sub-consultants or suppliers. This information will be reviewed annually to identify any potential mitigation measures that may be required;
- A bi-annual inspection of the condition of the principal access route to identify maintenance requirements; and
- An annual inspection of the condition of the new roads between Begbessou/Angovia and the site to identify maintenance requirements.

8.10.4 Summary of traffic impacts

See table overleaf.

Table 8-54 Summary of traffic impacts

Life cycte stage of concern CO, OP, CL*	Area of concern	Impact	Receptor sensitivity rating	Post-mitigation impact magnitude rating	Post-mitigation impact significance rating	Post-mitigation impact significance
CO, OP, CL	Increased Project-induced traffic on public roads	Potentially severance, driver and pedestrian delay, pedestrian amenity, fear and intimidation, accidents and safety	3	0 (negligible)	0	Negligible

* CO: Construction, OP: Operation, CL: Closure

8.11 Socio-Economic Impacts

8.11.1 Overview

This Section presents the results of the socio-economic impact assessment (SIA) and includes an evaluation of all potential impacts and benefits related to the construction, operation, closure and post-closure of the Project, and how these impacts will be managed. This Section does not, however, directly address the land use, cultural heritage, community health and safety, or ecosystem services impacts addressed in Sections 8.3, 8.12, 8.13, and 8.5, respectively. The Section is laid out as follows.

- Outline of the objectives for the impact assessment;
- Overview of approach and methods;
- Assessment of potential impacts;
  - Economic and Employment Impacts;
  - Displacement Impacts;
  - Population & Community Change Impacts; and
- Assessment of cumulative effects.

8.11.2 Objectives

The objectives of the SIA are to:

- Identify and investigate potential the social impacts of the Project on the baseline conditions described in Section 6.11 in all aspects and throughout all phases of the Project;
- Define appropriate mitigation measures to avoid or minimise potentially unacceptable negative impacts and benefit enhancement measures to enhance positive impacts; and
- Evaluate potential impacts in light of the above measures and make a determination of residual significance.

A Social Management Plan (Framework Plan) detailing the implementation of the proposed mitigation measures is presented in **Error! Reference source not found.**.

8.11.3 Economic and Employment Impacts

8.11.3.1 Taxes and Royalties

Source of Impact

National legislation – and specifically the 2014 Mining Code – establishes the legislative and financial framework applicable to mining companies operating in Côte d'Ivoire. The issuance of a mining permit entails a number of economic obligations in terms of payment of taxes and royalties to authorities of Côte d'Ivoire.

During the construction phase, Perseus will indirectly contribute to an increase in government income tax revenues through local hiring and to an increase in government VAT revenues through local procurement of services and goods. Perseus will need to sign an agreement with the Government to establish an applicable negotiated fiscal and custom regime.

In addition to the above, Article 7 of the Mining Code gives the Government of Côte d'Ivoire the right to acquire a 10% share (expandable to 15%) of the Company, during the exploitation phase and for the duration of the Project, as automatic compensation for the use of sub-soil resources.

Upon completion of the closure phase of the Project, Perseus will cease to create direct or indirect contributions to the economy of Côte d'Ivoire, however, direct, indirect and induced effects of the construction, operation and closure phases of the Project will have by then boosted the local, regional and national economy with irreversible positive effects.

In addition, commitments to rehabilitate the project site (see Closure and Rehabilitation Plan) will continue to require manpower for the duration of the closure phase.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Livelihoods – on the economic situation of the households in the study area;
- Living Conditions – on the quality of life and available services for the communities of the study area; and
- Local Governance – on the management of public policies and development plans in the area of Project influence.

Socio-Economic Receptors

Authorities of Côte d'Ivoire are the direct beneficiary – or social receptors – of the tax and royalties-related economic impacts of the Project. The Government benefits from direct, indirect, and induced effects of the collection of increased revenues for the national budget. Increased opportunities for public spending are intended as a significant benefit for all the people of Côte d'Ivoire. Impacted communities and relevant local authorities are assumed to share in most of these benefits on the hypothesis that the Government's fiscal policies will consider impacted areas as priorities for intervention.

Enhancement Measures

Côte d'Ivoire is a signatory member of the EITI principles to enhance the transparency of financial reporting and accountability in extractive sectors. Perseus will comply with EITI standards on financial reporting to ensure transparency of financial transfers to authorities of Côte d'Ivoire;

Perseus will engage with national and local authorities to encourage cooperation in the governance system to maximise the benefits of induced economic growth and payment of taxes to the central authorities for impacted communities.

Impact Evaluation

Under such premises, it is estimated that, during the construction phase, the economic impacts from the payment of taxes will be:

- Positive;
- Short-to-medium term (i.e., 18 months for construction – although considering pre-construction and exploration phases would extend the impact to medium-long term);
- Of low magnitude at national level – the contribution to the national budget is expected to be positive but of minor significance; and of medium magnitude at local level, where the influence on the regional budget is of moderate significance; and
- Of low-to-medium sensitivity at national level – the central Government is less dependent on Project funds to finance national development plans; and of medium-to-high sensitivity at local level where local authorities have restrained budgets to support their development plans.

It is also estimated that during the operation phase the economic impacts from the payment of taxes and royalties will be:

- Positive;
- Medium term (i.e., 6 years);
- Of medium magnitude at national level – the contribution to the national budget is expected to grow consistently as a result of the payment of royalties; and of

medium-to-high magnitude at local level where the influence of the Project will be determined by the weight of the financial transfers from the central to the regional level; and

- Of medium Sensitivity at national level – the central Government is less dependent on Project funds to finance national development plans but will have a steady stream of income over 6 years; and of high sensitivity at local level where local authorities have restrained budgets and will definitely benefit from a long-term source of revenues to carry out local development plans.

During the closure phase, it is expected that impacts will be of the same nature as, but of lower magnitude than, those of the construction phase. However, socio-economic consequences of mine closure do include retrenchment and loss of livelihoods. During the operation period, Perseus will strive to develop the socio-economic capabilities of the Angovia/Allahou Bazi community and the wider area so that negative consequences of mine closure are mitigated as far as possible. More specific mitigation measures will be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

8.11.3.2 Employment Opportunities

Source of Impact

Perseus will need a workforce during construction, many of whom will likely be sourced from the Project area (i.e., live within daily commuting distance). Most locally-sourced jobs will be accessible to unskilled or low-skilled candidates.

During operations, manpower will decrease to roughly 900 (see Table 3-5), most of whom are likely to be sourced in the Project area (i.e., live within daily commuting distance). Most of locally-sourced jobs will be accessible to unskilled or low-skilled candidates. Employment opportunities during the operation phase are likely to be longer term and include drivers, drillers, plant operators, mechanics, etc.

Commitments to rehabilitate project sites (see Closure and Rehabilitation Plan, see **Error! Reference source not found.**) will continue to require manpower and create employment opportunities for the duration of the closure phase.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Livelihoods – on the economic situation of the households in the study area;
- Professional skills – on the availability of qualifications and professional experience in the communities of the study area;

- Sensitivity and Poverty – on the marginalised conditions of individuals and households in the communities; and

- Socio-Economic Receptors.

All job seekers in the community - skilled or unskilled – are the primary beneficiaries of employment opportunities. However, jobs will be awarded on a regional, national, and international scale if specific, required skills cannot be found in the study area.

Enhancement Measures

Perseus has adopted the human resource/employment policy HRD-POL-011, which establishes internal best practices for recruiting standards. Policy requirements include the following:

- Preference accorded to local candidates with appropriate qualifications for project needs;
- Priority local hiring for unskilled positions; and
- Positions advertised locally (radio, local employment offices, etc.) to reach out to local communities.

In addition, Perseus will emphasise on capacity building efforts to improve skills of project staff and potential job seekers to facilitate their career path within the Project:

- Skills upgrading programmes for Project staff;
- Support for local education initiatives; and
- Local professional skills survey and establishment of a Local Job-Seekers Database.

An effective stakeholder engagement programme and internal grievance management will allow Perseus to:

- Manage the expectations of local authorities and communities through effective communication and engagement strategies on employment opportunities (type, duration, qualifications, etc.); and
- Ensure satisfaction guaranty from temporary and permanent staff recruited directly or working for the Project through contractors.

Impact Evaluation

Under such premises, it is estimated that during the construction phase the economic impacts from employment opportunities will be:

- Positive;

- Short-to-medium term (i.e., 18 months for construction – although considering pre-construction and exploration would extend the impact to medium-long term);
- Of medium magnitude at national level – the contribution to the national job market is expected to be positive and of moderate significance – potentially attracting an influx of job-seekers from other regions of the country; and of high magnitude at local level where job opportunities are extremely limited; and
- Of medium Sensitivity at national level – a high number of job seekers in Côte d'Ivoire are likely to be attracted to the opening of a new work site, although in a remote region; and of high sensitivity at local level where one of the most recurrent complaints from the communities is a lack of employment opportunities.

It is also estimated that during the operation phase, the economic impacts from employment opportunities will be:

- Positive;
- Medium-to-long term (i.e., up to 6 years);
- Of low magnitude at national level – the reduced number of positions as the Project moves from construction to operation will discourage further influx of job seekers; and of medium magnitude at local level, where some will be able to maintain a job and extend their contracts for up to 6 years while will need to be released; and
- Of low sensitivity at national level – migrants are more used to frequent resettlement in new areas as they seek new job opportunities; and of medium-to-high sensitivity at local level – local communities are more dependent on the evolution of the project and less resilient when facing negative shocks.

During closure phase, it is expected that impacts will be of the same nature as, but of lower magnitude than in the construction phase. However, the socio-economic consequences of mine closure often include retrenchment and loss of livelihoods. During the operation period Perseus Yaoure will strive to develop the socio-economic capabilities of the Angovia community and the wider area so that negative consequences of mine closure are mitigated as far as possible.

More specific mitigation measures must be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

8.11.3.3 Business Opportunities

Source of Impact

Through the Project phases Perseus will need to procure local goods and services to support construction and operation plans. Detailed information on procurement needs for these phases is not yet available at this stage. In general terms, the types of goods and services required will inter alia include:

- Transport, catering, laundry, food supply, and security services for camps;
- Supply of construction vehicles and equipment; and
- Provision of construction materials including aggregates/sand, concrete, and building materials.

Commitments to rehabilitate project sites (see Closure and Rehabilitation Plan, **Error! Reference source not found.**) will continue to require goods and services and create business opportunities for the duration of the closure phase.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following;

- Livelihoods – on the economic situation of the households in the study area;
- Professional skills – on the availability of qualifications and professional experience in the communities of the study area; and
- Stakeholder Mapping – on the identification of potential project partners that could support the development of business opportunities at regional level.

Socio-Economic Receptors

The main socio-economic beneficiaries for this impact are local businesses (where existent) and regional and national companies alike.

Enhancement Measures

Perseus will adopt international best practices for the procurement of local goods and services. Practices will require actions at the level of stakeholder engagement, data management and local content, such as:

- Facilitate access to information on procurement to help local businesses remain competitive;
- Facilitate partnerships between regional finance and training providers and local businesses;
- Local enterprise development activities to support the establishment of sustainable local businesses; and
- Local business surveys and establishment of a Vetted Local Supplier Database.

Impact Evaluation

Under such premises, it is estimated that during the construction phase the economic impacts upon business opportunities will be:

- Positive;
- Short-to-medium term (i.e.18 months for construction – although considering pre-construction and exploration would extend the effect to medium-long term);
- Of high magnitude at national and, more importantly, regional level – the contribution to the national/regional market of goods and services is expected to be positive and of high significance. If competitive, contractors or sub-contractors for selected services could come from the urban centers of Bouaflé, Yamoussoukro or Abidjan; and of medium magnitude at local level where the market would benefit greatly from business opportunities but lacks the capacity to offer the quality and quantity of products and services required by the Project; and
- Of medium-to-high Sensitivity at national/regional level – many companies are striving to consolidate their volume business; and of medium sensitivity at local level where the presence of established companies that can compete on the market is significantly lower.

It is also estimated that during the operation phase the economic impacts upon business opportunities will be:

- Positive;
- Medium-to-long term (i.e. up to 6 years);
- Of high magnitude at national/regional level – less contracts will be available than during the construction phase and some required services and goods will be of differing natures, but business opportunities can extend over a time span of up to 6 years; of medium magnitude at local level – awarding fewer contracts will likely enhance competition in the market, but local businesses could develop in the medium-long run and be in a position to compete with other regional, national, or international bidders; and
- Of high sensitivity at national/regional level – there are many regional and national companies that would be interested in securing business opportunities in the Project area; and of medium sensitivity at local level – local communities would benefit greatly from Project opportunities, but will need time to understand Project needs and develop supply capacities.

During the closure phase, it is expected that impacts will be of the same nature as, but of lower magnitude than, as during the construction phase. However, socio-economic consequences of mine closure often include retrenchment and loss of livelihoods. During the operation period, Perseus Mining will strive to develop the socio-economic capabilities of the Angovia community and the wider area so that negative consequences of mine closure are mitigated as far as possible.

More specific mitigation measures will need to be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

Table 8-55 Economic and Employment Impacts

Phase	Impact	Impact Description	Impact Assessment: Direction	Duration	Magnitude	Sensitivity of Receptors	Evaluation of Post-Mitigation Impact
Construction	Payment of National Taxes	Perseus will indirectly contribute to an increase in government revenues from income taxes through local hiring.	P	S/M	L	L/M	Minor Positive
	Payment of Regional Taxes	Perseus will directly and indirectly contribute to an increase in government revenues from VAT through local procurement of services and goods. Perseus will pay taxes to central and local governments to ensure the delivery of all public services (e.g. waste, customs, etc.), as per applicable legislation.	P	S/M	M	M/H	Moderate Positive
	Employment Opportunities at National/Regional Level	PERSEUS will need a workforce of 1000-2000 units during construction, 500 of whom will likely be sourced from the Project area (i.e., live within daily commuting distance).	P	S/M	M	M	Moderate Positive
	Employment Opportunities at Local Level		P	S/M	H	H	Major Positive
	Business Opportunities at National/Regional Level	PERSEUS will source locally depending on the availability of services and goods for Project needs.	P	S/M	M	M/H	Minor Positive
	Business Opportunities at Local Level		P	S/M	M	M	Moderate Positive
Oper at	Payment of National Taxes and Royalties	Perseus will indirectly contribute to an increase in government revenues from income taxes through local hiring.	P	L	M	M	Moderate Positive

	Payment of Regional Taxes	Perseus will directly and indirectly contribute an increase in government revenues from VAT through local procurement of services and goods. Perseus will pay taxes to central and local governments to ensure the delivery of all public services (e.g. waste, customs, etc.), as per applicable legislation Perseus will comply with the new Mining Code	P	L	M/H	H	Moderate Positive
	Employment Opportunities at National/Regional Level	Perseus will need a workforce of 800 during operations, most of whom are likely to be sourced in the Project area.	P	M/L	L	L	Minor Positive
	Employment Opportunities at Local Level		P	M/L	M/H	M/H	Major Positive
	Business Opportunities at National/Regional Level	Perseus will source locally depending on the availability of services and goods for Project needs.	P	M/L	H	H	Minor Positive
	Business Opportunities at Local Level		P	M/L	M	M	Moderate Positive
Closure	Payment of National Taxes and Royalties	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	L	L/M	Minor Positive
	Payment of Regional Taxes	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	M	M/H	Moderate Positive
	Employment Opportunities at National/Regional Level	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	M	M	Moderate Positive
	Employment Opportunities at Local Level	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	H	H	Major Positive
	Business Opportunities at National/Regional# Level	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	M	M/H	Minor Positive
	Business Opportunities at Local Level	During closure phase, it is expected that impacts will be of the same nature as in the construction and operations phase, but with a lower magnitude.	P	S/M	M	M	Moderate Positive

8.11.4 Displacement Impacts

8.11.4.1 Loss of agricultural land

Source of Impact

Perseus will need to acquire 1,109 ha of Project footprint during the pre-construction and construction phases. Of these, 463.5 ha will require soil stripping. It is estimated that roughly 15% of the land in the study area is agricultural land (Land Use Report, 2D Consulting, 2015). Agricultural land is defined as land with standing crops (or cultivated), in preparation, or young fallow land (resting for a maximum of 24 months).

Impacts will occur before the construction machinery is mobilised and will endure for the life of the Project. This ESIA assumes that the project will not displace any primary residential structures and therefore that resettlement will not be required. Land acquisition will only cause economic displacement, which requires a livelihood restoration process. Therefore, it is anticipated that no physical displacement will take place as a result of impacts upon residential land or structures. Similarly, it is expected that no significant temporary or permanent limitations/restrictions of land use will occur outside the project footprint.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Livelihoods – on the economic situation of the households in the study area;
- Agricultural Income – on the type of local agricultural techniques, crops and revenues; and
- Land Tenure and Management – on the administration of land rights in the communities according to customary rights.

Socio-Economic Receptors

The main socio-economic receptors of this impact will be the communities of the five priority villages, with some possible, occasional, implications for other households in the larger study area.

Mitigation Measures

Perseus will define social management plans to offset negative impacts on livelihoods as a consequence of the land acquisition strategy. The Framework Livelihood Restoration Plan is attached as **Error! Reference source not found.**. Adopted measures include the following:

- Establishing compensation rules for loss of productive land and/or standing crops that adhere to national regulations and IFC PS 5; and

- Defining an entitlement matrix to outline compensation packages for categories of impacted people.

In addition, Perseus will develop measures to support livelihood restorations and agricultural development, including the following:

- Support development of livelihood projects on agriculture intensification;
- Replacement (in cash or in-kind) of any built or planted assets lost due to land acquisition by the Project, including locational advantages and access;
- Livelihood restoration programmes to restore agricultural production; and
- Work with local authorities to improve local land use planning and support development initiatives (Land Use Plan and Community Development Plan).

Impact Evaluation

Under such premises, it is estimated that impacts from economic displacement of agricultural land will be:

- Negative;
- Long Term (i.e. for the duration of the Project);
- Of Medium-to-High Magnitude – economic displacement impacts are concentrated in the local area of influence; therefore, the level of the land take for the impacted communities is of high significance; and
- Of High Sensitivity – in the local area of influence, agricultural and land-based economic activities are the primary source of income for most households.

8.11.4.2 Loss of forest and bush land

Source of Impact

Perseus will need to acquire 1,109 ha of Project footprint during the pre-construction and construction phases. Of these, 463.5 ha will require soil stripping. It is estimated that almost 85% of land in the study area is non-agricultural land (Land Use Report, 2D Consulting, 2015). This sub-category of impacts considers bush land (e.g., savannah), forestland, and old fallow land (resting for more than 24 months).

Impacts will occur before the construction machinery is mobilised and will endure for the life of the Project. It is not anticipated that impacts upon residential land or structures will trigger physical displacement.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Livelihoods – on the economic situation of the households in the study area;
- Eco-system Services (see Section 8.5) – on the portion of livelihoods derived from hunting and fishing activities, or from the use of other naturally-available products (e.g. wood, straw, clay, medicinal herbs, wild fruits, etc.); and
- Land Tenure and Management – on the administration of land rights in the communities according to customary laws.

Socio-Economic Receptors

The main socio-economic receptors of this impact will be the communities of the five priority villages, with some possible, occasional, implications for other households in the larger study area.

Mitigation Measures

Perseus will establish social management plans to offset negative impacts upon livelihoods as a consequence of the land acquisition strategy. Adopted measures include the following:

- Livelihood restoration programmes to support the development of alternative livelihood activities;
- Defining an entitlement matrix to outline compensation rights for categories of impacted people; and
- Establishing compensation rules for loss of land that adhere to national regulations and IFC PS 5;

In addition, Perseus will support – in accordance with local and national authorities – programmes to restore habitats that can contribute to supporting ecosystem services.

Impact Evaluation

Under such premises, it is estimated that impacts from economic displacement of agricultural land will be:

- Negative;
- Long Term (i.e. for the duration of the Project);

- Of High Magnitude – economic displacement impacts are concentrated in the local area of influence; therefore, the level of the land takes for the impacted communities is estimated to be of high significance; and

- Of High Sensitivity – in the local area of influence, households rely heavily on locally available products (e.g. fish, game meat, woods, etc.).

8.11.4.3 Loss of artisanal mining sites

Source of Impact

Perseus will need to acquire 834 ha of Project footprint during the pre-construction and construction phases. Of these, 582 ha will require soil stripping (see Table 3-2). Figure 6-60 maps artisanal mining sites located within the Project footprint that will be affected by economic displacement impacts.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Livelihoods – on the economic situation of the households in the study area;

- Artisanal Mining Income – on the type of mining techniques, work organisation, and revenues;

- Migrations and Population Movements – on the influx of foreign workers attracted to artisanal mining opportunities in the region; and

- Land Tenure and Management – on the administration of land rights in the communities according to customary rights.

Socio-Economic Receptors

In terms of land-related impacts, the main socio-economic receptors will be the ASM communities of the five priority villages, with some possible occasional implication for other households in the larger study area. In terms of work activities, the main receptors will be the artisanal miners (both locals and outsiders) who will need to look for new mining sites to preserve their incomes.

Mitigation Measures

Perseus will define social management plans to offset negative impacts on livelihoods as a consequence of the land acquisition strategy. Adopted measures include:

- Livelihood restoration programmes to support the development of alternative livelihood activities;

- Compensation packages for loss of access to economically-valuable assets that adhere to IFC PS 5; and
- Defining an entitlement matrix to outline compensation rights for categories of impacted people.

In addition, Perseus will support local and national authorities in achieving the following:

- Improving local land use planning and supporting development initiatives (Land Use Plan and Community Development Plan); and
- Providing support to government initiatives to encourage artisanal mining activities within the legal framework of the 2014 Mining Code.

Impact Evaluation

Under such premises, it is estimated that impacts from economic displacement of agricultural land will be:

- Negative;
- Long Term (i.e. for the duration of the Project);
- Of High Magnitude – economic displacement impacts are concentrated in the local area of influence; therefore, the level of land takes for the impacted communities is estimated to be of high significance; and
- Of High Sensitivity – in the local area of influence, households rely heavily upon artisanal mining, which is the principal cash-generating activity in the community.

8.11.4.4 Rehabilitation of land in the project footprint

Source of Impact

Perseus is committed to sustainably close and rehabilitate the Project site at the conclusion of the life of the Project. Insofar as it is technically and economically possible, progressive rehabilitation will keep environmental liabilities to a minimum during the operation phase.

All mine infrastructure (plant, camp, etc.) will be removed as required by Art. 145 of Act No. 2014-138, 24 March 2014 of the Mining Code and affected areas graded and re-vegetated. Discussions about Project buildings and facilities that could be retrofitted or left standing to be used by local communities or government will be held during Mine Closure Planning, closer towards the planned end of the mine life.

Socio-Economic Baseline Influencing Factors

Socio-economic conditions will need to be re-assessed at a later stage of the Project.

Socio-Economic Receptors

The main socio-economic receptors of this impact will be the communities of the five priority villages, with some possible, occasional, implications for other households in the larger study area.

Enhancement Measures

Perseus will establish enhancement measures and management plans to maximise benefits of the rehabilitation programme after a re-assessment of the socio-economic profile of the community.

Impact Evaluation

Under such premises, it is difficult to estimate the magnitude and sensitivity of the impact, however, we can expect that impacts will be of an opposite nature but similar magnitude to those of the construction phase and therefore:

- Positive;
- Long Term;
- Of Medium-to-High Magnitude; and
- Of High Sensitivity.

Table 8-56 Economic Displacement Impacts

Phase	Impact	Impact Description	Impact Assessment				Evaluation of Post-Mitigation Impact
			Direction	Duration	Magnitude	Sensitivity of Receptors	
Construction and Operations	Loss of agricultural land (cultivated, in preparation, young fallow)	Perseus will acquire 834 ha of Project footprint during construction; of these, 582 ha will require soil stripping. It is estimated that 15% of the land acquisition will affect agricultural land and associated livelihoods.	N	L	M/H	H	Moderate Negative
	Loss of forest, bush and old fallow land	Perseus will acquire 834 ha of Project footprint during construction; of these, 582 ha will require soil stripping. It is estimated that 85% of the land acquisition will affect non-agricultural land and associated livelihoods.	N	L	H	M	Moderate Negative
	Loss of artisanal mining sites	Perseus will acquire 834 ha of Project footprint during construction; of these, 582 ha will require soil stripping. A presence of roughly 100 artisanal mining sites was surveyed in the study area (2014). However, since government action in May 2015, this has reduced considerably, therefore the impact is very much reduced.	N	L	M	M	Moderate Negative
Closure	Rehabilitation of land in the Project footprint.	Perseus will rehabilitate the great majority of the 834 ha of Project footprint.	P	L	M/H	H	Moderate Positive

8.11.5 Population and Community Change Impacts

The Project will lead to population growth and community change, which will induce both positive and negative impacts in the Project Area. In-migration may have already begun and is expected to continue through to the end of the Operations Phase. In-migration is expected to be concentrated in the vllages of Angovia and Allahou Bazi, or, if this area becomes too crowded or expensive, in the towns of Akakro, Kouakougnanou or new settlement areas. The major cause of this population growth is likely to be the in-migration of workers and job-seekers for direct, indirect and induced Project-related opportunities.

Benefits of population growth include the following:

- Induced economic growth – newcomers, by satisfying their need for shelter, food and other necessities, will contribute to the induced economic development boom in the area, as discussed in sections above.

Notwithstanding these benefits, there are potential negative impacts to be considered:

- Increase in pressure on social facilities, infrastructure, and government services;
- Induced inflation;
- Increase in conflict between locals and outsiders; and
- Increase in breaches of human rights and poor labour conditions.

8.11.5.1 Influx of people and increase in pressure on social facilities, infrastructure and public services

Source of Impacts

Perseus will need a workforce during construction and 250 during operations. In addition to directly hired project labour, it is also possible that people could move towards project locations in the hope of finding work directly with the Project or to gain benefit from the indirect economic opportunities that the Project may bring, such as selling goods or services to the Project or its workforce.

During construction and operation, the expected influx of workforce will increase pressure on the use of communal infrastructure (houses, roads, schools, and clinics), natural resources (water), and public services (electricity, waste disposal).

During the closure phase, impacts of population influx and pressure on social facilities, infrastructure and public services are of the same nature and magnitude as those of the construction phase.

Impacts on health infrastructure (clinics, hospitals) are considered in the Community Health, Safety and Security impact assessment (Section 8.13).

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Housing – Availability and type of residential structures in the study area;
- Water – Sources, availability and quality of potable water in the study area (see also Sections 8.1 and 8.2 on surface/groundwater and drinking water impacts of the Project);
- Electricity – Sources and availability of public electricity network services in the study area; and
- Waste – Waste management and disposal in the study area.

Socio-Economic Receptors

The main socio-economic receptors of this impact are the local communities in the study area that might experience degradation of their infrastructure and services. In-migrants – depending on whether they decide to settle in pre-existing villages or temporary camps - might not be able to access basic services such as water, sanitation and electricity.

Mitigation Measures

Perseus will work with local authorities to prevent degradation of local infrastructure and services in impacted communities through:

- Procuring goods and services locally whenever possible;
- Ensuring that per capita baseline water availability is maintained throughout the lifecycle of the Project;
- Supporting the development of community infrastructure and services via the CDF; and
- Recruit locally to avoid competition for the limited number of residential structures in the study area.

Stakeholder engagement activities, a good communication strategy, as well as monitoring and management plans will help Perseus mitigate negative impacts resulting from an unmanaged influx of job seekers and workers. These actions include:

- On-going in-migration monitoring along with regular feedback to local communities;

- On-going monitoring of local economy (livelihoods) and health with regular feedback to those affected;

- All employment will be managed via Local Employment Offices, which will be established in existing large settlements with capacity to accommodate population growth. Any individuals who approach work areas will be referred to the nearest Employment Office. No employment will be offered directly at open pit sites or work areas; and

- Local Economic Participation Plan to support the sustainable development of the local economy.

Impact Evaluation

Under such premises, it is estimated that during the construction phase impacts from population influx and increase in pressure on social facilities, infrastructure, and government will be:

- Negative;

- Short-Medium Term (i.e., for the duration of construction activities);

- Of High Magnitude – direct and indirect opportunities presented by the opening of a work site in Côte d'Ivoire is expected to generate a significant interest among job seekers and opportunity hunters from Côte d'Ivoire and neighboring countries (free circulation of people in the ECOWAS region); and

- Of High Sensitivity – in the local area of influence, massive migratory influxes have already occurred irrespective the Project stage, and have resulted in increasing pressure on local infrastructure (waste, road, water, etc.), In addition, Project-led, influx of workers and job seekers will need to be carefully managed to avoid further straining on infrastructure.

Although some of the impacts will be irreversible, during the operation phase it is expected that reduced labour requirements will gradually alleviate pressure on local infrastructure and services. Impacts are estimated to be:

- Negative;

- Medium-Long Term (i.e., for the duration of the Project);

- Of Low-to Medium Magnitude – direct and indirect opportunities will gradually decrease during the transition towards the operation stage of the Project. By the same token, the influx of job seekers and the pressure on local infrastructure is expected to decrease proportionally; and

- Of Low-to-Medium Sensitivity – it is expected that the need for an upgrade of services and infrastructure will be perceived – and addressed – mostly in the construction phase. During operations, with the decrease of migratory influx and pressure on infrastructure, the communities are expected to be more resilient to negative shocks and to benefit from any upgrade to infrastructure and services conducted in the construction phase.

8.11.5.2 Influx and Induced Inflation

Source of Impacts

Perseus will need workforce during construction, and 250 during operations. In addition to labour directly employed by the Project, it is possible that additional people may migrate towards project locations in search of work, either directly with the Project or to gain employment in indirect economic opportunities that the Project may bring.

In addition, the Project will bring about economic opportunities for local, regional and national businesses through procurement of goods and services. During construction, the land acquisition strategy and compensation packages are expected to increase the availability of cash in the community.

Economic growth, an influx of workers, loss of land, and the presence of cash in the community are all factors expected to induce an increase in local prices of housing and land, and an increase in prices for basic market goods (vegetables and fruits, rice, etc.).

During the operation and closure phases, induced inflation impacts are expected to endure, although eventual price stabilisation is likely.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Economy and Livelihoods – on the living conditions and revenues of households in the study area; and

- Housing – Availability and type of residential structures in the study area.

Socio-Economic Receptors

The main socio-economic receptors of this impact are the local communities in the study area that might experience an increase in price of basic goods. Additionally, vulnerable households are expected to be the most impacted.

Mitigation Measures

Perseus will need to establish mitigation measures in relation to the livelihood restoration programme and community development plans, such as:

- Establish monitoring and management plans to ensure that Project-led inflation does not negatively impact vulnerable households;
- Give preference, where possible, to in-kind compensation packages over cash-compensation entitlements to avoid circulation of excessive amount of liquidity;
- Encourage households to accept cash compensation packages in installments over a number of years rather than opting for lump sum solutions;
- Recruit locally to avoid competition with local community members for limited existing housing infrastructure; and
- Promote savings, safe investments and banking services as a form of sound management of financial entitlements.

In addition, Perseus will work with local authorities and partners to ensure that local communities are aware of the inflation risks, receive trained on financial management and can make informed choices about their earnings.

Impact Evaluation

Under such premises, it is estimated that - in the construction phase - impacts of population influx and induced inflation will be:

- Negative;
- Long Term - inflation is expected to develop during the construction phase but its effects will last over a much longer period of time;
- Of Medium-to-High Magnitude – it is not possible to predict exactly to what extent inflation will affect the study-area, but the inflow of investment and money is expected to generate a significant increase in prices, especially in some markets (e.g., housing); and
- Of Medium Sensitivity – an increase in prices will have a bi-dimensional (positive/negative) effect on some portions of the community (e.g. house owners, traders, etc.) and purely negative effects on some other categories of people (e.g. vulnerable households).

Inflation is expected to drag negative effects also in the operation phase, as increase and decrease of prices do not usually proceed with the same pace. Reduction of workforce and cessation of land acquisitions are expected to prevent inflation rates to grow higher in the operation phase, but it is highly unlikely that pre-project inflation rates can be restored. As a consequence, impacts are estimated to be:

- Negative;
- Long Term (i.e. for the duration of the Project and possibly also after its conclusion);
- Of Low-to Medium Magnitude – the inflation rate is expected to stabilise after the first years of steady increase in prices; and
- Of Medium Sensitivity – an increase in price will have a bi-dimensional (positive/negative) effect on some portions of the community (e.g. house owners, traders, etc.) and purely negative effects on some other categories of people (e.g. vulnerable households).

Impacts in the closure phase are expected to be of a similar nature but of a more unpredictable magnitude. Specific mitigation measures will need to be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

8.11.5.3 Social cohesion and increase in community conflicts

Source of Impact

Social cohesion refers to the quality and quantity of interactions between members of a community (intra-community) and between members of different communities (inter-community). It describes the capacity to function and develop together based on integration and the ability to manage conflicts within the community/between neighbouring communities. Social cohesion must be considered a continuous process interweaving a broad fabric of issues, such as access to education and employment, poverty and socioeconomic inequalities, socioeconomic and cultural diversity, and access to communication and information. A high level of community cohesion implies respect for persons as individuals, sensitivity to ethnic and socioeconomic differences, and a sense of belonging to the community or, as the case may be, to a group of local communities.

A change in the overall socio-economic features of the study area – such as may be caused by an influx of job-seekers, transition from an agriculture-based economy to a cash or wage-based economy, and economic growth in general - is expected to influence relationships among community members (including household members) and between different communities (e.g., between foreigners and locals), and introduce changes in the power structures within traditional village governance patterns during the construction, operation and closure stages of the Project.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Population and Demography – on the migratory and demographic trends of the study area;
- Religion and Ethnicity – on the historical, traditional and cultural profile of the communities of the study area;
- Sensitivity and Poverty – on the identification of vulnerable groups and indicators;
- Local Governance – on the management of public policies and development plans in the area of Project influence; and
- Historical context – on the main clashes and conflicts inter and intra communities registered in the recent history of the study area.

Socio-Economic Receptors

The main socio-economic receptors of this impact are the local communities and authorities in the study area that might experience a degradation of the rule of law and an increase in insecurity and violent conflicts. Foreigners or outsiders might become the object of frustration and tension if social performances in the study area are not well managed. Women, as a vulnerable group with limited decision-making power in the community and in the household are particularly vulnerable to negative impacts induced by socio-cultural and economic change (e.g., increase of domestic violence, divorce, intimidation, etc.).

Mitigation Measures

Perseus will need to establish mitigation measures in relations to engaging and partnering with local stakeholders, such as:

- Creating or strengthening credible governance structures - including influential members of the Community - to manage, monitor and supervise Project-related impacts;
- Supporting the extension of policing services at the sub-prefectural level to prevent the intensification of violent conflicts;
- Conducting community health and security awareness campaigns at religious institutions, local governments, schools, and health posts;
- Cooperating with UN bodies (i.e., the United Nations Operation in Côte d'Ivoire, or UNOCI/ONUCI) for national reconciliation and appeasement of local communities; and

- Supporting the development of community infrastructure and services - in particular improved night-time lighting.

Moreover, Perseus will need to monitor in-migration trends, Sensitivity indicators, restoration of livelihood projects, and community development plans. Recording good social-performances in the study area is the key to enhancing governance structures and lowering the potential for conflicts in the study area.

Impact Evaluation

Under such premises, it is estimated that - in the construction phase - impacts arising from reduced social cohesion and increases in community conflicts will be:

- Negative;
- Short-to-Medium Term (e.g. the pre-construction and construction phases will register the highest influx of workers and job-seekers);
- Of Medium-to-High Magnitude – it is expected that the socio-economic changes in the demographic, economic and cultural profile of the community will be of significant proportion; and
- Of High Sensitivity – local governance structures and populations have already dealt with similar trends caused by the development of artisanal mining sites in the study area. The non-management of these socio-economic changes has already resulted in violent conflicts and in an UN-led initiative to appease communities.

Social cohesion is expected to improve in the operation phase when the workforce is smaller and mostly on long-term assignments. However, the gradual reduction of manpower during the closure phase might generate tensions, conflicts or the perception of higher insecurity between workers and job-seekers and between locals and outsiders. As a consequence, impacts are estimated to be:

- Negative;
- Short-to-Medium Term - tensions are expected to arise only in the beginning of the releasing phase. Laid-off workers are expected to find new employment in the study area or elsewhere in the short-medium run;
- Of Low-to Medium Magnitude – the number of laid-off workers should be limited and gradual and the process of releasing should be well-explained to employees and local communities from the start. The highest pressure on social change and challenge on local governance is expected to happen during the construction phase and to gradually fade out as the Project progresses; and

- Of Medium Sensitivity – local governance structures and populations are expected to be better prepared and more able to deal with social, economic, cultural diversity and change, as a result of previous experience.

Impacts in the closure phase are expected to be of a similar nature but of a more unpredictable magnitude. Specific mitigation measures will need to be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

8.11.5.4 Labour and Working Conditions

Source of Impacts

Inappropriate management of occupational health and safety hazards could lead to unsafe working conditions and accidents, injuries, or illnesses among workers. Exposure to dust and fine particulates during all phases of open pit development and operation put workers at risk of contracting respiratory diseases and eye conditions. Exposure to excessive noise levels during all phases of open pit development and operation can permanently damage workers' health.

The influx of workers and job-seekers, business opportunities for local entrepreneurs, and a lack of awareness of minimal legal rights and standards of working conditions in the study area are all factors that are expected to increase the risk of breaching health and safety regulations and labour standards of labour and working conditions, especially during construction.

Impacts on labour and working conditions are expected to be at their highest magnitude during the construction phase when the influx of workers will reach its peak. Impacts will endure during operation and closure phase, although at a lesser magnitude.

Socio-Economic Baseline Influencing Factors

Socio-Economic Baseline Influencing Factors include the following:

- Legislative Framework – on national and international standards regarding labour and working conditions; and

- Working Activities and Professional Skills – on the professional profile and working activities of the households in the study area.

Socio-Economic Receptors

The main socio-economic receptors of this impact are the job-seekers (locals or outsiders), especially those with little knowledge of workers' rights and labour conditions seeking employment through indirect or induced opportunities.

Mitigation Measures

Perseus will incorporate labour rights and working conditions standards in the management plans, through the following commitments:

- Employment procedures and conditions during construction will conform to international standards with respect to protection of human rights;
- Employment practices and working conditions will conform to the requirements of IFC PS 2 (Labour and Working Conditions), the national Labour Code and ILO Standards; and
- Anti-discrimination policies will be applied to ensure fair and transparent practices.

In addition, Perseus will adopt safeguard measures to preserve the working conditions for its employees. Measures include:

- Strict procedures will be adopted for hazard identification and risk assessment and for definition and implementation of appropriate mitigation measures to ensure a safe workplace. Relevant information will be communicated to all Project personnel;
- A comprehensive health and safety plan will be developed prior to commencement of any activities to ensure that workers are aware of the risks associated with activities;
- Open pit machinery such as trucks and dozers will have ROPS, air-conditioned, dustproof and sound proof cabins to protect operators;
- Personal eye, breathing and hearing protection will be provided to all workers for use in designated areas of the open pit and for specific noisy and/or dusty tasks; and
- Strict HSE conditions governing labour and working conditions will be applied to contractors and sub-contractions to ensure that all people working for the Project are treated according to the same basic standards.

Perseus will need to conduct stakeholder engagement and communication campaigns to inform communities and local authorities about their HSE plans and standards, recruiting practices, and non-discrimination policies.

Impact Evaluation

Under such premises, it is estimated that - in the construction phase - impacts from labour and working conditions will be:

- Negative;

- Short-term – (e.g., the pre-construction and construction phases will register the highest influx of workers and job-seekers and the highest number of contracts awarded to local and regional businesses);

- Of Low-to-Medium Magnitude – the number of local workers represents a significant portion of the total amount of job opportunities that will be available with the Project, but the level of this impact on the labour force within the study area is considered to be of low-to-medium magnitude; and

- Of Medium-to-High Sensitivity – rural communities in the area are used to working in the household, plantations, and family agricultural plots. Thus they possess little awareness of national or international standards of labour and working conditions.

Labour conditions are expected to improve in the operation phase – the workforce will be smaller, mainly on long-term assignments, easier to monitor. Impacts are estimated to be:

- Negative;

- Short-to-Medium Term – the longer the assignment the easier it should be to identify poor labour relations or health and safety practices and act accordingly;

- Of Low Magnitude – the number of local workers subject to lax standards of health and safety and labour relations is expected to lessen as the Project moves forward; and

- Of Low-to-Medium Sensitivity – rural communities are used to working in the household, plantations, and family agricultural plots. They possess little awareness of national or international standards of labour and working conditions. However, their knowledge can improve over time with appropriate awareness campaigns.

Impacts in the closure phase are expected to be of a similar nature but of a more unpredictable magnitude. Specific mitigation measures will need to be identified after a careful re-evaluation of the socio-economic profile of the study area towards the end of the operation phase.

Table 8-57 Population and Demography Impacts

Phase	Area of concern	Impact Description	Impact Assessment				Evaluation of Post-Mitigation Impact
			Direction	Duration	Magnitude	Sensitivity of Receptors	
Construction	Influx of people and increase in pressure on social facilities, infrastructure, and government	Increased use of communal infrastructure (houses, roads, schools, and clinics), natural resources (water) and public services (electricity, waste disposal) due to population growth - degradation of communal services and resources due to over-use.	N	S/M	H	H	Moderate Negative
	Influx and Induced Inflation	Inflation of goods and services will reduce the purchasing power of local residents not employed with the Project.	N	L	M/H	M	Minor Negative
	Social cohesion and increased community conflicts	Increase of social tension as a result of pressure on socio-economic and cultural change due to economic growth and in-migration of outsiders - in particular youth and single men. Expected impacts include: challenge to local governance structure, tensions between locals and outsiders, tensions between workers and job-seekers, insecurity, vandalism and eruption of violent conflicts.	N	S/M	L/M	M/H	Moderate Negative
	Labour and Working Conditions	Inappropriate management of occupational health and safety hazards could lead to unsafe working conditions and accidents, injuries or illnesses amongst workers. The influx of workers and job-seekers (hence their availability to work), the business opportunities for local entrepreneurs and the low awareness of minimal legal rights and standards to working conditions in the study area are all factors that are expected to increase the risk of breaching health and safety regulations and	N	S	L/M	M/H	Minor Negative

		standards of labour and working conditions.					
Operations	Increase in pressure on social facilities, infrastructure, and government	Increased use of communal infrastructure (houses, roads, schools, and clinics), natural resources (water) and public services (electricity, waste disposal) due to population growth - degradation of communal services and resources due to over-use.	N	M/L	L/M	L/M	Minor Negative
	Induced Inflation	Inflation of goods and services will reduce the purchasing power of local residents not employed with the Project.	N	L	L/M	M	Minor Negative
	Increase in conflicts between locals and outsiders	Increase of social tension as a result of pressure on socio-economic and cultural change due to economic growth and in-migration of outsiders - in particular youth and single men. Expected impacts include: challenge to local governance structure, tensions between locals and outsiders, tensions between workers and job-seekers, insecurity, vandalism and eruption of violent conflicts.	N	S/M	L/M	M	Minor Negative
	Labour and Working Conditions	Inappropriate management of occupational health and safety hazards could lead to unsafe working conditions and accidents, injuries or illnesses amongst workers. The influx of workers and job-seekers (hence their availability to work), the business opportunities for local entrepreneurs and the low awareness of minimal legal rights and standards to working conditions in the study area are all factors that are expected to increase the risk of breaching health and safety regulations and standards of labour and working conditions, particularly during the construction phase.	N	S	L	L/M	Minor Negative
Closure	Increase in pressure on social facilities, infrastructure, and government	Increased use of communal infrastructure (houses, roads, schools, and clinics), natural resources (water) and public services (electricity, waste disposal) due to population growth - degradation of communal services and resources due to over-use.	N	S	L/M	L	Minor Negative
	Induced Inflation	Inflation of goods and services will reduce the purchasing power of local residents not employed with the Project.	N	L	U	U	Minor Negative

	Increase in conflicts between locals and outsiders	Increase of social tension as a result of pressure on socio-economic and cultural change due to economic growth and in-migration of outsiders - in particular youth and single men. Expected impacts include: challenge to local governance structure, tensions between locals and outsiders, tensions between workers and job-seekers, insecurity, vandalism and eruption of violent conflicts.	N	S/M	L	L/M	Minor Negative
	Labour and Working Conditions	Inappropriate management of occupational health and safety hazards could lead to unsafe working conditions and accidents, injuries or illnesses amongst workers. The influx of workers and job-seekers (hence their availability to work), the business opportunities for local entrepreneurs and the low awareness of minimal legal rights and standards to working conditions in the study area are all factors that are expected to increase the risk of breaching health and safety regulations and standards of labour and working conditions, particularly during the construction phase..	N	S	L/M	L/M	Minor Negative

8.12 Cultural Heritage

8.12.1 Source, Receptors, and Significance of Potential Impacts before Mitigation

Direct impacts on cultural heritage arise from the construction of the mine, associated processing facilities and transport infrastructure. Cultural heritage impacts arise during the construction phase and are associated with the loss of archaeological cultural remains, as well as the loss of sacred spaces, locations and features. As noted, no intangible cultural heritage assets were identified from existing records or during the field visits.

Indirect effects on cultural heritage could arise from the physical effects on foci for traditional beliefs and practices within nearby communities (i.e., cemeteries and sacred forests).

8.12.1.1 Construction phase

Cultural heritage impacts arise during the construction phase and are associated with the loss of known and unknown archaeological sites within the TSF area (pottery scatters and potential sub-surface cultural heritage remains), the impact on the cemeteries and sacred forests in the area of the TSF, as well as chance finds of material culture across the wider development area.

Without mitigation, the loss of in situ archaeological cultural heritage as well as sacred sites would be permanent and irreversible, and hence major. The loss of archaeological cultural heritage, and the associated knowledge which would be obtained from them, as well as the loss of sacred sites which play a role in the social and religious life of the surrounding communities would represent a significant effect on the local cultural and archaeological cultural heritage.

8.12.1.2 Operation and closure phase

There is no identified direct impact to additional receptors during these phases. However there is a risk that unknown archaeological cultural heritage remains may be encountered during these phases.

8.12.2 Management and Mitigation Measures and Significance of Impacts after Mitigation

8.12.2.1 Construction phase

Mitigating the effect of development on cultural heritage is proposed through:

- Relocation of sacred sites (cemetery and sacred forests);
- Implementation of a 'Chance Find Procedure' (see **Error! Reference source not found.**) during construction.

Relocation plan

The Relocation Plan to be developed by Perseus will address the following:

- Cemetery: Decision on a suitable location for the site of the old cemetery will be undertaken in collaboration with the village authorities and in accordance with community customary practice, needs and concerns.

- Sacred Forests: Issues relating to the sacred forests are the responsibility of the head of the families who hold the land and any relocation of the site and associated conditions will to be negotiated with, and undertaken in conjunction with, the relevant leaders.

Further details and agreement will be set out in a Social Management Plan, including arrangements for community liaison during the construction phase that will ensure customary practices are recognised and respected, including the observation of cultural taboos identified by the communities.

Satisfactory implementation of these plans would have a Low post-mitigation impact.

Pre-Construction Archaeological Investigation

A programme of archaeological investigation (pre-commencement investigation) of an area of cultural heritage remains within the TSF area will be undertaken prior to construction.

The initial archaeological and heritage study by 2D identified this area as being undisturbed by past mining/construction activity, which in addition to a large scatter of pottery on parts of the surface, indicates potential for further archaeological remains at the location. Pre-construction evaluation would allow a greater understanding of the risk of encountering archaeological remains during the main construction phase, and any impact which may result. Further details of preconstruction evaluation are detailed in **Error! Reference source not found.**.

The archaeological recording of history and culture of an historical area of the landscape, with evidence of occupation over an extended period of time would offer scope to share skills and knowledge with the academic community of Côte d'Ivoire, contribute to the understanding of the history of the area and the sense of place for local communicates which would have a beneficial residual effect.

Chance Find Procedures

The Chance Find Procedure detailed in **Error! Reference source not found.** will inform site staff of requirements to report any discoveries and to protect archaeological discoveries pending further advice on mitigation measures.

If these mitigation measures are implemented satisfactorily, post-mitigation impacts are expected to be minor.

8.12.2.2 Operation and closure phase

The Chance Find Procedure detailed in Appendix 33 will inform site staff of requirements to report any discoveries and to protect archaeological discoveries pending further advice on mitigation measures.

It is unlikely that in the closure phase additional archaeological remains will be found.

8.12.3 Summary of cultural heritage impact

See table overleaf.

Table 8-58 Cultural Heritage Impacts

Phase	Area of concern	Impact Description	Impact Assessment				Evaluation of Post-Mitigation Impact
			Direction	Duration	Magnitude	Sensitivity of Receptors	
Construction	Archaeological objects and artifacts	Destruction or loss of objects and artifacts during construction activities	N	L	M	M	L
	Sacred sites, sacred forests and cemeteries	Destruction of sacred sites and cemeteries during construction activities	N	L	H	H	M
Operations	Archaeological objects and artifacts	Destruction or loss of objects and artifacts during operation (e.g., extension of pit)	N	L	L	M	M
Closure	None						n.a.

8.13 Community Health and Safety

The objectives of the community health and safety impact assessment are to:

- Identify and investigate potential health impacts of the Project on the baseline conditions described in Section 6.13 throughout all phases of the Project
- Define appropriate mitigation measures to avoid or minimise potentially unacceptable negative impacts and benefit enhancement measures to enhance positive impacts
- Evaluate potential impacts in light of the above measures and make a determination of residual significance.

A Community Health Management Plan detailing the implementation of the proposed mitigation measures is presented in **Error! Reference source not found.**.

The community health and safety impact assessment draws on information from the baseline study (Section 6.13); IFC Guidance Notes; publically available literature; the in-house household survey and focus group interviews completed by rePlan in February 2015; and other discipline studies presented in this report. The impact assessment and mitigation plan follows International Finance Corporation guidance (IFC Performance Standards and Guidance Notes, 2012) to meet expectations outlined in IFC Performance Standard 4.

8.13.1 Assessment methodology of impacts

The assessment methodology for community health and safety is approach in a similar manner to socio-economic impacts (see Section 7.4). The assessment is qualitative rather than quantitative. This is because community health and safety impacts are diverse, including economic, environmental and social determinants of health.

In the analysis of environmental determinants of health, there is a lack of specific causal pathways of the indirect effects of development projects (e.g. mine development) on health outcomes to enable quantitative estimates on improvement of health status. That is, beyond human health risk assessment, the direct and indirect effects of mining projects on community health and safety have not been researched on a quantitative level.

Similar to the rating of socio-economic impacts (see Section 7.4), the discussion of these criteria will then inform the designation of an impact as of minor, moderate or major significance:

- Minor significance indicates barely distinguishable in the population, infrequent, short-term, dispersed impacts that do not result in elevated awareness or concern among stakeholders or result in measurable change in the well-being of the population;

- Moderate significance indicates clearly distinguishable in the population, intermittent, medium-term, localised impacts that result in elevated awareness or concern among stakeholders or result in measurable change in the well-being of the population;

- Major significance indicates highly distinguishable, frequent, long-term, impacts that pose a high enough result in strong concern among stakeholders or result in substantive changes in the well-being of the population; and

- Impacts of minor significance require tracking; they must be monitored to confirm that they remain low. Impacts that are of moderate and high significance require active management by the Project Management.

8.13.2 Source, Receptors, and Significance of Impacts

8.13.2.1 Community Health

Source of Impact

Employment and income are positive determinants of health. Project employment and income and indirect employment and income within the study area (Area of Direct Influence, Indirect Area of Influence and Regional Area of Influence) are sources of positive impact on general health status and wellbeing. The project will require employment during the construction, operations phase and closure phase. The closure phase will involve a reduced workforce and decreased Project employment, effecting decreased income as a result of the Project. Some out-migration may occur at the closure phase and again post-closure, especially from any informal settlements that remain. However, these residents may remain if they have become integral to the economy and culture of the areas of influence.

Local and regional capacity of health services will indirectly affect health and well-being if in-migration occurs and access to health services is reduced. Any changes in limitations to health care access, such as increased income availability for health care services may also affect general health and well-being indirectly.

On a more specific scale, mining and other natural resource projects have been associated with lifestyle changes such as consumption of alcohol, tobacco use, drug use and change in diet that can have negative impact (IFC 2012).

Sexually transmitted diseases (STDs), including HIV/AIDS, syphilis and gonorrhoea have been associated with mining and other natural resource projects internationally (IFC 2012). The baseline study presents evidence that such impacts have already occurred in these areas.

The Project has the potential to contribute to the spread of communicable diseases through the influx of people into the region. Labour demands are highest during the construction phase and lowest during the closure phase. Expectations are often elevated during construction and influx often peaks at this time. Influx can occur locally, regionally, nationally and internationally. This pattern is already evident in the Area of Direct Influence. There may be some out-migration of migrants that entered the areas of influence during the construction phase; however, some former migrants may remain during the operations phase. In the operations phase, the informal settlements of the construction phase may become more formal and semi-urbanised. Overcrowded living conditions, poor hygiene and sanitation, inadequate liquid and solid waste management, and a lack of control of disease and disease vectors could continue but to a lesser degree than in the construction phase. In the closure and post-closure phases, sanitation in the areas of influence would likely remain consistent with that in the operations phase. With out-migration and reduced populations in the areas of influence post-closure, sanitation conditions could improve overall when compared to the operations phase. These conditions will impact community exposure to disease.

The project site will feature facilities with stagnant water, including the tailings management facility and smaller water management ponds. These stagnant water bodies will introduce permanent potential mosquito breeding sites to the Project area. However, mosquito control measures will be implemented by Perseus. Due to the temporary nature of mine roads and production areas, mine sites commonly feature informal pools if water earthworks grading has left uneven ground. These pools will also serve as potential breeding sites for mosquitos. Mosquitos are often vectors for malaria and yellow fever.

The closure phase will significantly decrease demand on surface water or groundwater sources. In the post-closure phase, no water intake will be required.

Baseline Influencing Factors

Baseline influencing factors include the following:

- Employment and income – the socio-economic status of the households in the study area;
- Health – morbidity and mortality in the study area;
- Access to health services;
- Access to surface and groundwater for human and agricultural use – on sanitary conditions; and
- Sanitation – on exposure to communicable disease.

Community Receptors and Effects before Mitigation

Construction Phase

Project workers and their families will potentially increase their health status and wellbeing for the duration of their employment in the construction phase. Any households benefiting from indirect employment effects of project construction will also be positively affected. These general effects will occur in the Direct Area of Influence, Indirect Area of Influence and Area of Regional influence.

On a more specific scale, if workers adopt lifestyle changes such as consumption of alcohol, tobacco use, drug use and change in diet these will negatively affect the health of these workers and their families can be impacted negatively. Without mitigation, there is potential for increased prevalence of cardiovascular disease, drug addiction, tobacco use and diabetes in the Direct Area of Influence and Indirect Area of Influence. Current high incidence could be further exacerbated without mitigation.

If influx occurs during the construction phase, access to health services will be effectively reduced, as without mitigation, more people will be relying on an unchanged number of health centres, facilities and staff. This has the potential to affect waiting periods, duration and severity of illness for workers, their families and other community members. Children and health compromised or vulnerable individuals in addition, may be discouraged from seeking treatment at the Angovia Health Centre. For those with increased income as a result of direct or indirect employment, current cost limitations to access to health services may be elevated. Support for increased health services will reduce potential for morbidity and mortality and as well as contribute to worker health and availability for work. Positive and negative effects may be confounded by the universal health care policy and implementation.

If influx occurs during the construction phase, access to clean water will effectively be reduced, as without mitigation, more people will be relying on an unchanged number of improved drinking water sources. Use of surface water resources for drinking water supply may increase. Already extremely poor sanitation conditions will likely decrease and there will be opportunity for increased exposure to communicable diseases. Sanitation and hygiene will be negatively affected if migrants do not construct formal sanitation systems and more people begin to share existing sanitation facilities. An increase in water-related communicable disease in the Area of Direct Influence and Area of Indirect Influence is likely without mitigation. Influx often leads to the emergence of informal settlements, which are often characterised by poor housing and inadequate liquid and solid waste management. In these communities, the poor sanitation and hygiene conditions can lead to lack of control of communicable disease and disease vectors (e.g., typhoid and mosquitos, respectively). If improved drinking water sources and improved sanitation facilities are not increased or increased at a lower rate than the rate of influx, incidence of water-related diseases will increase for all communities receiving influx, including any new communities that may occur informally. These diseases include diarrhoea, dysentery, typhoid and malaria). Influx may also impact access to agricultural water if current agricultural-based water sources are used by migrants for drinking water. Quality of drinking water may be affected if people and animals begin to share drinking water sources. Communities within the Indirect Area of Influence are at increased risk than in the Direct Area of Influence because sanitary conditions are already poor.

The health and safety baseline indicated malaria is the most prevalent disease in the areas of influence. Mosquitos are carriers of malaria. Without mitigation, the project may unintentionally cause increase incidence of malaria through increased breeding grounds for mosquitos. The Project can increase breeding grounds in the Direct Area of Influence by creating bodies of stagnant water. Such areas can occur as a result of excavation and levelling of earthworks. Any excavation or preparation of uneven ground could collect water and become breeding grounds for mosquitos if not drained immediately and rectified. Community members traveling in areas adjacent to Project production, plant and tailings construction areas are most at risk of increased exposure to mosquito-borne disease (e.g. malaria and yellow fever).

Sexually transmitted diseases (STDs), including HIV/AIDS, syphilis and gonorrhoea have been associated with mining and other natural resource projects internationally (IFC 2012) and are predominantly associated with influx and increased prostitution. Project workers choosing to participate in prostitution or increase the number of sexual partners can lead to increased exposure and incidence of HIV/AIDS in men, women, and children. This pattern is already evident in the Direct Area of Influence (see Section 6.13.4) and could be exacerbated with increased influx into the Direct Area of Influence and Indirect Area of Influence.

<u>Operation Phase</u>

Assuming access to health services is improved overall, households benefiting from direct or indirect employment during the operation phase would generally continue to experience improved health status and well-being. Households not benefiting from direct or indirect employment may become disenfranchised, in terms of income and access to health services. Vulnerable groups include female headed households, elderly and disabled persons. Effects will continue to occur throughout the study area.

Changes in diet as result of increased income could affect non communicable diseases (e.g. diabetes, cardiovascular disease), if new food choices are poor. As demonstrated in the baseline study above, there is already some evidence that this has occurred in the Direct Area of Influence and Indirect Area of Influence. If substance abuse and alcoholism became prevalent during the construction phase, this would likely continue into the operations phase as employment sources, behaviours and lifestyle became established.

When compared to baseline levels, there will likely be a higher incidence of sexually transmitted diseases (STDs), as mining related lifestyle and behaviours are adopted and stabilised in the communities within the Area of Direct Influence during the operation phase. HIV/AIDS is a non-curable STD present in the Project areas of influence. Project workers, their families, and women and girls in the Area of Direct Influence are the most vulnerable potential receptors.

Even if out-migration occurs, poor sanitation conditions may remain if mitigation does not occur. During the operations phase net access to surface and ground water for human and agricultural use would still be decreased when compared to baseline levels. If there is increased pressure on drinking water sources, communities and livestock may commence to share water sources if access is convenient. Any poor living conditions would continue to negatively affect community health and incidence of water-borne, water-based, water-related diseases will increase overall for all communities in the Direct Area of Influence and Indirect Area of Influence. These diseases include diarrhoea, dysentery and typhoid.

The most vulnerable populations for water-related diseases are communities with already high incidence of diarrhoea (Alley and N'da Koffi Yobouekro in the Indirect Area of Influence), people residing in any new informal settlements, and communities or families who commence to share water sources with livestock. As such, an increase in water-related communicable disease in the Area of Direct Influence and Area of Indirect Influence is possible.

If overcrowded living conditions occur as a result of net influx, incidence of respiratory diseases (e.g. tuberculosis) may increase, especially if access to health facilities is reduced. People in Amanifla in the Indirect Area of Influence are currently most vulnerable. The communities of Patizia and Akakro are also vulnerable.

In terms of direct effects, assuming that at least some mosquitos are malaria-carrying, an increase in potential breeding sites for mosquitos at the project site will effect an increased potential for exposure to malaria by Project workers and likelihood of increased incidence of disease in this population. New informal settlements have more opportunities for stagnant water pools to form than in permanent settlements, which leads to an increased number of potential breeding sites and, potentially, increased incidence of malaria. Any new informal settlements would be at risk. Communities with already elevated malaria incidence (Alley and Amanifla) are vulnerable.

Closure and Post-Closure Phase

Community members who had participated in direct or indirect employment could be negatively affected if alternative employment is not readily available or people do not diversify their skills to enable to take up new employment or enterprise at Project close. Any net loss of income would negatively impact health and wellbeing when compared to that of the operations phase. However, long-term positive impacts of the project, such as improved living conditions and job readiness, would be able to sustain a net overall increase in health and wellbeing during the closure phase, when compared to baseline conditions. Any long-term lifestyle changes adopted by former mine employees could impact affected workers and families beyond the closure phase.

As project related employment and income decrease, former mine workers may adapt to the lifestyle and behaviour of their new employment source of enterprise. This could potentially initiate reduction of incidence of sexually transmitted diseases (STDs) during the closure phase. Women and girls would remain the most vulnerable potential receptors.

Without mitigation or lifestyle choices made during the operations phase to improve sanitation conditions, sanitation conditions could remain reduced when compared to baseline. Under reduced sanitary conditions, community exposure to disease would remain without mitigation.

The Mine Closure and Rehabilitation Plan (**Error! Reference source not found.**) describes closure and rehabilitation activities at the Project site. The water pooled on the tailings dam will disappear during the closure phase, reducing the opportunity for mosquito breeding in this facility. Other water storage ponds may remain in place, depending on community preferences, for fish breeding or other beneficial after-uses. At closure, the open pit will be allowed to fill with water, and a stagnant pond will potentially generate a mosquito breeding area which could affect malaria transmission in the Direct Area of Influence. Small informal pools of water on roads and former earthworks will be covered and re-vegetated, further reducing potential breeding sites for mosquitos and transmission of malaria in these areas.

Mitigation and Enhancement Measures

Perseus will work with local authorities to prevent degradation of local infrastructure and services in impacted communities through:

- Ensuring that per capita baseline water availability is maintained throughout the lifecycle of the Project;
- Supporting the development of community infrastructure and services, including provision of health services, improved sanitation and improved drinking water sources;
- Supporting anti-mosquito breeding schemes;
- Building independent work-camps where labour cannot be sourced locally, that include improved sanitation facilities; and
- Developing the socio-economic capabilities of the Angovia community and the wider area to increase likelihood of Project beneficiaries finding alternative employment and income.

Stakeholder engagement activities, a good communication strategy, as well as monitoring and management plans will help Perseus mitigate negative impacts resulting from an unmanaged influx of job seekers and workers. These actions include:

- On-going in-migration monitoring along with regular feedback to local communities;

- On-going monitoring of health services, health and health impact pathways (e.g., number of bodies of stagnant water, number of people with access to improved sanitation facilities) with regular feedback to those affected;

- Cooperation and awareness sessions addressed to community, including culturally appropriate knowledge transfer regarding vulnerabilities of mining communities and potential impacts of lifestyle choices (e.g., financial management, behaviours and lifestyle choices, good hygiene practices and sanitation, disease exposure, transmission and reduction). Outreach is often provided through a range of media including community-based workshops or communications programmes flyers located in prominent positions in the workplace and affected communities; and

- HIV/AIDS awareness communication strategies will address common myths and present supportive scientific evidence for relevant lifestyle choices.

Impact Evaluation after Mitigation and Enhancement

With the implementation of mitigation effects described above, increased community exposure to disease will be prevented and thereby disease is reduced, even in communities with high vulnerability. Any residual increase specific community exposure to disease will be balanced out by the positive impacts of employment and income that affect increased health status overall.

During the construction phase, the post-mitigation/enhancement community health impacts from project construction will generally be:

- Neutral to Positive;

- Short-to-medium term (i.e., 18 months for construction);

- Of medium to high magnitude magnitude overall within Area of Direct Influence and Area of Indirect Influence;

- Of medium sensitivity at local and regional level for general health and wellbeing;

- Of medium Sensitivity within Area of Direct Influence; high Sensitivity within Area of Indirect Influence, in terms of community exposure to disease: – exposure to disease is already high in specific communities with the Area of Indirect Influence; and

- Of low significance overall – the construction phase is too short to observe long-term changes in general health and well-being; and reduction in community exposure will be challenging during this period. An exception may be overcrowded housing conditions as people will seek accommodation in the villages adjacent to the mine site.

During the operation phase, the community health impacts from project operation will generally be:

- Overall positive;
- Long term (i.e. 6 years);
- Of medium overall within Area of Direct Influence and Area of Indirect Influence;
- Of medium sensitivity at regional level for general health and wellbeing;
- Of medium Sensitivity within Area of Direct Influence; high Sensitivity within Area of Indirect Influence, in terms of community exposure to disease: – exposure to disease is already high in specific communities with the Area of Indirect Influence; and
- Of moderate significance overall.

During the closure phase, the community health impacts from Project closure will generally be:

- Neutral to negative;
- Short-to-medium term (i.e., 18 to 36 months for closure);
- Of medium magnitude overall within Area of Direct Influence and Area of Indirect Influence;
- Of medium sensitivity at local and regional level for general health and wellbeing – assuming long-terms effects of Project operations have been established; and
- Of moderate significance overall.

*8.13.2.2 **Community Road Safety***

Source of Impact

Project traffic will peak during specific periods within the construction phase as large trucks deliver multiple parts of heavy plant for construction on site. Project traffic will stabilise to a relatively low and consistent rate during the operations phase with regular delivery of supplies. Influx to the areas of influence could also increase the number of road users, including pedestrians. Project traffic will significantly reduce during the closure phase, when compared to the operations phase. Road conditions are also a determining factor and are discussed in Section 6.10.

Baseline Influencing Factors

Baseline influencing factors include the following:

- General road safety culture in Côte d'Ivoire; and
- Community Road Safety –traffic related injuries.

Community Receptors and Effects before Mitigation

Although the Project would generate a relatively small increase in traffic on public roads within the area of influence, any Project related traffic incident would affect the safety performance of the Project negatively. General road safety culture is poor and traffic related injuries are already high in the Area of Direct Influence. Without mitigation measures in the community, project-related traffic is at increased risk of exposure to road users acting with unsafe behaviours. In this regard, likelihood of accident and injuries are increased when compared to expectations for international projects. In addition, an influx to the areas of influence would lead to an increased opportunity for traffic related accidents and injuries. In absence of awareness training and enforcement, injury could occur if safety awareness of driver or road users is low.

During construction, operations and closure phases, injury could occur if safety awareness of driver or road users remains low or users become complacent over time. Road users from communities along the transportation and workers' commute routes are potential receptors, as are Project-traffic drivers.

Mitigation and Enhancement Measures

Perseus will work with local authorities to prevent degradation of local infrastructure, including local and regional roads.

Stakeholder engagement activities, a good communication strategy, as well as monitoring and management plans will help Perseus prevent potential negative impacts resulting from a poor in-country safety culture. These actions include the following:

- Clear expectations regarding road safety culture, road safety behavior and road safety training, provided to workers and contractors;
- On-going monitoring of traffic safety (e.g., near misses, reports from communities, reports from project traffic) with regular feedback to those affected; and

- Knowledge transfer to workers and affected communities regarding road user awareness with advice on strategies for interacting with industrial traffic.

Impact Evaluation after Mitigation

With the implementation of mitigation effects described above, Project related traffic related injuries will be minimised. For all Project phases, any residual increase will be indistinguishable in the areas of influence and of Low significance.

8.13.2.3 Infrastructure and Equipment Design and Safety

Source of Impact

The standard of Project design, construction and closure methods affect worker and community safety for the duration of the construction phase and Project life.

Baseline Influencing Factors

Baseline influencing factors include the following:

- Infrastructure and Equipment Design and Safety- in-country safety culture influence.

Community Receptors and Effects before Mitigation

The standard of Project design and construction methods influences the reliability of equipment safety, probability of accidents and pollution spills and emergencies and thereby affects worker and community safety for the duration of the construction phase and Project life. Construction design and methods completed by companies experienced in large, international projects, with formal professional registration and certification maximises adherence to international standard practices (IFC 2012). Perseus has met these standards (see Section 3). These safety provisions are protective to community health and wellbeing.

The Conceptual Mine Closure and Rehabilitation Plan (**Error! Reference source not found.**) has been prepared with the objective to minimise excess Project risk to communities in the Project Area when the site is closed and returned to the Community.

Mitigation and Enhancement Measures

Perseus will be clear about its expectations of subcontractors during all phases. Perseus will continually monitor and evaluate companies' performance, including performing spot checks on-site, to ensure that the expected level of safety culture is being adhered to.

Impact Evaluation after Mitigation

The above safety provisions are protective to community health and wellbeing.

During the construction, operation and closure phases, the community health impacts from infrastructure design and safety will generally be:

- Negative (in case of equipment failure, spills etc.);
- Short/medium and long-term (construction/closure and operation, respectively);
- Of low magnitude within national context; medium magnitude in areas of influence – some international standards already exist within area of influence but other contexts such as artisanal mining currently exhibit low safety standards although Project effects on these are expected to be low and artisanal mining has recently been pushed back by Government in the Project area;
- Of medium sensitivity; and
- Of low significance overall.

8.13.2.4 Hazardous Materials Management and Safety

Source of Impact

Hazardous materials will be brought onto site by Perseus and subcontracted companies for construction activities. These may include oils; diesel fuel; hydraulic fluid; resins and lead. Waste generated during the construction phase may include used oils; soil contaminated with hydraulic fluid or diesel fuel; and used lead solder. The introduction of large quantities of hazardous materials onto the Project site (e.g., cyanide briquettes, industrial cleaning agents) will occur towards the end of the construction phase. During the operations phase, the use of hazardous materials will be consistent at the Project site.

The Project will reduce non-hazardous and hazardous waste during the closure phase. Hazardous waste sites will be prepared for long-term closure during the closure phase which will reduce risk during the closure phase. The Closure and Rehabilitation Plan (**Error! Reference source not found.**) describes how hazardous waste landfills will be closed and rehabilitated at the Project site.

Water management will be scaled back during and after the closure phase. The Closure and Rehabilitation Plan (**Error! Reference source not found.**) includes provisions protective to water contamination in the closure and post-closure phase. This plan will be updated throughout the mine life. Towards the end of the mine life, the Plan will be more specific with respect to closure objectives and the technical design and organisational procedures to achieve them.

In addition, community and industrial waste is often collected, re-used, recycled and often sold by communities that are unaware of the associated hazards. As such, the hazardous materials are a potential source of chemical poisoning risk for communities close to the Project site.

Baseline Influencing Factors

Baseline influencing factors include the following:

- Hazardous Materials Management and Safety – influence of in-country regulation and culture towards hazardous materials management.

Community Receptors and Effects before Mitigation

During construction and operation, the most hazardous materials such as Sodium Cyanide will be transported in solid (e.g., briquette) form wherever possible, which limits the opportunity for immediate impact to nearby communities and thereby reducing risk; however, the risk remains in the event the solid reagents, briquettes etc. were to become exposed to water and dissolved. Diesel will be transported in tank trucks. Potential receptors are communities in the Direct Area of Influence and along the transportation route.

The general lack of hazardous materials management and safety enforcement and awareness in Côte d'Ivoire are risks to the management of hazard materials by project workers and subcontractors. Without mitigation (self-enforcement and knowledge exchange), lack of awareness by project workers, contractors and suppliers could lead to inconsistent management, transport and disposal of hazardous materials. Workers and their families in their home communities are potential receptors, if people remain unaware of hazards and choose to collect and reuse, recycle or resell Project waste. Hazardous materials, such as industrial cleaning agents, are also potential risks, if workers choose to adopt their use in their home and local communities without awareness and proper management and safety.

Closure methods will minimise excess Project risk to communities in the Direct Area of Influence. These provisions are protective to community health and wellbeing.

Mitigation and Enhancement Measures

Perseus will endeavour to have Cyanide transported and managed under Cyanide Code criteria reducing risk of release and exposure to workers and nearby communities. A Water Management Plan (see **Error! Reference source not found.**) has been developed as part of the ESIA to reduce contamination of ground and surface water. Mine run-off, tailings and chemicals at the Project site remain potential sources of environmental risks to community health and safety. Potential receptors are communities near to the Project site and downriver; and will be determined as part of the detailed emergency response planning process.

The international standard policies, self-enforcement, training and knowledge exchange with local communities and government agencies; will potentially positively affect hazardous materials management and safety locally, regionally and nationally. These safety provisions are protective to community health and wellbeing.

Impact Evaluation after Mitigation

During the construction, operation and closure phases, the community health impacts from hazardous infrastructure design and safety will generally be:

- Neutral – based on balance of increase in hazardous materials introduced into the area of influence with increase in quality of hazardous materials management;
- Long-term (overall);
- Of medium magnitude in areas of influence – hazardous materials are already in use and uncontrolled by artisanal miners;
- Of medium Sensitivity – determinants are Project based and population based; and
- Of minor significance overall – based overall improved management of hazardous materials in the area of influence.

8.13.2.5 Emergency Preparedness and Response[10]

Source of Impact

Any serious medical event or chemical release would constitute an emergency and require an appropriate and prepared response.

Baseline Influencing Factors

Baseline influencing factors include the following:

- Emergency Preparedness and Response – national, regional and local network and capacity for emergency response.

Community Receptors and Effects before Mitigation

The current lack of emergency preparedness and response facilities and networks in Côte d'Ivoire indicates that external emergency planning is likely weak. Weak external capacity for emergency planning and response exposes risk to communities within the Direct Area of Influence. Perseus will need to be proactive and self-sufficient in its needs to respond to, and manage, an emergency.

[10] See also Section 8.11.4 that provides a more general summary of Perseus's Emergency Preparedness and Response policy.

A draft Internal Emergency Preparedness and Response Plan has been developed (see **Error! Reference source not found.**). The international standard policies, training, self-enforcement, cooperation and knowledge exchange with local communities and government agencies, will potentially positively affect the capacity for emergency preparedness and response locally for the duration of the Project life. In this respect, Perseus will encourage communities and regional government to develop an External Emergency Preparedness and Response Plan to complement the internal plan and establish a positive and balanced interrelationship of internal and external emergency planning. Emergency plans will be tested and revised by Perseus (internal plans) and by authorities (external plans).

For the Project, the following aspects of the External Emergency Preparedness and Response Plan are important (see also Section 8.11.4):

- Definition of information and notification chain(s) within government/regulatory agencies (who needs to be informed, who has which responsibility and access to/control over resources), following notification of the authorities by Perseus that an emergency situation has occurred;
- Media information chain (local radio) – such as warnings of water pollution downstream;
- Evacuation procedures for the local affected population;
- Awareness of operations and their risks and preparedness to respond (e.g., sufficient stocks of CN antidote, sufficient capacity of beds in local hospital);
- Preparedness of state/community emergency response teams (fire brigade) and awareness of risks and potential emergency scenarios, availability of PPE adequate for specific risks such as respirators, full-body suits etc.;
- Knowledge of site plan by ambulance teams (fastest access to critical points such as process plant, CN storage, explosive storage);
- Training requirements of key people (police, ANDE/CIAPOL, hospitals and local health centres) and alignment of their training plans with Perseus training plans;
- Commitment to coordinated emergency drills between Perseus and police, fire fighters, ANDE/CIAPOL, etc., and aligned plans for drills; and
- Nomination of community representatives in the preparation of the external plan, and in the planning of and participation in, drills.

Mitigation and Enhancement Measures

Perseus will work with local authorities to strengthen the national emergency response network in the Project area and develop a project specific external emergency preparedness and response plan. These provisions are protective to community health and wellbeing.

Impact Evaluation after Mitigation

During the construction, operation and closure phases, the community health impacts from emergency response will generally be:

- Positive – Provisions are protective to community health and wellbeing;
- Long-term (overall);
- Of low magnitude in areas of influence – emergency events are not planned occurrences but do need to be prepared for in case of occurrence;
- Of low to medium sensitivity – determinants are Project based and governance based; and
- Of Low significance – based on normal operating conditions.

8.13.2.6 Community Security

This section is closely related to social cohesion and increase in community conflicts (see Section 8.11.5).

Source of Impact

As identified in the baseline study, ex-combatants are a determinant of community safety and security in Côte d'Ivoire. Concentration of ex-combatants is reported to be high in the region although none were identified during the socio-economic study. If ex-combatants seek employment at the Project or seek other indirect opportunities in the areas of influence, then ex-combatant concentration will increase.

The Project will include security staff at the Project site and camp to carry out the functions of access and perimeter control, deter and prevent theft, assist with vehicle and journey management and maintain records of all operational events. Security staff will be expected to provide a professional, efficient and reliable security service, maintaining high behavioural and ethical standards. Security employees will be required to adhere to all applicable regulations, e.g., ex-military personnel will be required to fully disclose all relevant information under legislation of Côte d'Ivoire. Such enforcement may discourage ex-combatants and military personnel from seeking employment opportunities within security services at the Project. During the operations phase, the Project will be characterised with additional security risks as a gold producer. Gold is a target for theft in all countries.

Baseline Influencing Factors

Baseline influencing factors include the following:

- Private Security Services – governance and inclusion of ex-combatants or ex-military personnel;
- Violence – and proliferation of small arms and weapons; and
- Sexual violence – ex-combatants are associated with sexual violence.

Community Receptors and Effects before Mitigation

Construction

Social cohesion may be reduced and violence will increase if ex-combatants and ex-military personnel seek job opportunities at the Project or otherwise migrate into the Direct Area of Influence and Indirect Area of Influence during the construction phase. Women and girls are potential receptors of violence, including sexual violence if security personnel do not meet the above Project expectations. Note that if the Project deters ex-combatants and ex-military from the area, sexual violence may decrease.

If tension arises between in-migrants and established residents during the construction phase, men, women and girls could be at increased risk of violence against them. People of ethnic or religious minorities may also be at increased risk. Differences between these groups could exacerbate the potential for violence and crime, which could potentially affect communities in the Direct Area of Influence and Indirect Area of Influence.

In terms of Project security services, ex-military personnel and ex-combatants are often attracted to this industry and may be attracted to the Project in this respect. Legislation of Côte d'Ivoire deters their involvement, partially based on an association with sexual violence. Without mitigation, there are potential negative impacts of Project related security services on community violence and security.

Operation

The potential for communal tensions to arise between in-migrants and established residents will continue through the operations phase. This may be exacerbated if there are ethnic or religious differences in these populations. The potential for communal tension will decrease if stability and equitable project benefits are perceived. If tensions arise, women and girls would be at increased risk of violence against them.

The potential for sexual violence will depend on residual concentration of ex-combatants in the areas of influence. In the long term, the potential for sexual violence will decrease as the country continues to stabilise and ex-combatants adopt new lifestyles and behaviours. This decrease will become evident as the operation phase progresses.

Closure

There will be potential for social tension to arise between in-migrants and established residents during the closure phase if long-term disenfranchisement is perceived by the non-migrant communities. This may be exacerbated if there are ethnic or religious differences in these populations. The potential for communal tension will decrease if stability and equitable project benefits are perceived. If tensions arise, women and girls would be at increased risk of violence against them, including sexual violence if such behaviours have continued in the region at that time.

Mitigation and Enhancement Measures

As described in the socio-economic effects section (Section 8.11.5), Perseus will need to monitor in-migration trends and vulnerability indicators, including incidence of sexual violence and perceived security. Recording good social and health performances in the study area is key to protecting community security and lowering the potential for conflicts and acts of violence in the Direct Area of Influence and Indirect Area of Influence.

Perseus will need to establish mitigation measures in relations to engaging and partnering with local stakeholders, such as:

- Supporting the extension of policing services at the sub-prefectural level to prevent the intensification of violent conflicts;
- Conducting community health and security awareness campaigns at religious institutions, local governments, schools, and health posts;
- Cooperating with UN bodies (i.e., ONUCI) for national reconciliation and appeasement of local communities – this will include strategies to identify ex-combatants and ex-military personnel within the community and within the Project security services; and
- Supporting the development of community infrastructure and services - in particular improved night-time lighting.

In terms of project security services, Perseus may seek support from government authorities and non governmental organisations to aid preventative planning, evaluation, monitoring and follow-up to ensure security services providers meet Project expectations.

Impact Evaluation after Mitigation

During the construction phase, the community health impacts on community security, including violence, will generally be:

- Negative;
- Short Term;
- Of Medium Magnitude – based on expected levels of violence rather than changes in the demographic, economic and cultural profile of the community, which will be significant;
- Of High Sensitivity – in the past (pre-household survey) violent conflicts have occurred in the Direct Area of influence and resulted in an UN-led initiative to appease communities; and

- Of Moderate Significance – based on clearly distinguishable increase in violence during the construction phase.

Social cohesion and community security is expected to improve in the operation phase when the workforce is smaller and mostly on long-term assignments. As such, incidence of violence is expected to decrease during this time. Based on this, the community health impacts on community security, including violence, during Project operation will generally be:

- Negative;
- Short-to-Medium Term - tensions are expected to arise only in the beginning of the operations phase;
- Of Low-Magnitude – security should stabilise as employment stabilises as the operation phase progresses;
- Of Medium Sensitivity – local governance structures and populations are expected to be better prepared and be more adapted to new lifestyles; and
- Of Minor Significance – based on barely distinguishable increased violence during the operation phase.

During the closure phase, the impacts on community security, including violence, will generally be:

- Negative;
- Short Term;
- Of Medium Magnitude – assuming long-term disenfranchisement is perceived by a proportion of established residents (non-migrant communities);
- Of Medium Sensitivity – violent conflicts have occurred in the Direct Area of Influence in the, however, sensitivity (vulnerability) will have reduced as stability in country progresses away from the current post-conflict context; and
- Of Low to Moderate Significance – based on potential for barely or clearly distinguishable increase in violence during the closure phase.

8.13.3 Conclusions

With successful outcomes and mitigation measures in place, Project impacts on community health will be both negative and positive, and of minor to moderate significance. In the long-term, communities in the regional area of influence, including the Direct Area of Influence and the Indirect Area of Influence will benefit from increased employment and income, which will improve health status in general in the area.

Communities will be most vulnerable and impact magnitude highest during the short-term construction phase when influx into the areas of influence may be high and Project support at its earliest stages. Stability during the long-term operations phase will provide opportunity for long-term and positive effects. Closure effects are often similar to construction effects, however, with the country progressing from the current post-conflict context, in-country stability will affect communities to a lesser magnitude than during the construction phase.

8.13.4 Summary of community health, safety and security impacts

See table overleaf.

Table 8-59 Summary of community health, safety and security impacts

Phase	Area of concern	Impact Description	Impact Assessment				Evaluation of Post-Mitigation Impact
			Direction	Duration	Magnitude	Sensitivity of Receptors	
Construction	Community Health	Increase in communicable diseases including STDs due to the influx of people into the region	N	S/M	M	M/H	L
	Community Health	Increase in vector-borne disease due to stagnant water	N	S/M	L	M/H	L
	Community Health	Improvement of health status and wellbeing in community, especially among workers	P	S/M	H	M/H	H
	Community Health	Lifestyle changes such as consumption of alcohol, tobacco use, drug use leading to health problems (e.g., cardiovascular diseases)	N	S/M	L	M/H	L
	Community Health	Pressure on health infrastructure due to influx of workers	N	S/M	M/H	M/H	L
	Community Health	Access to clean water will effectively be reduced due to influx of workers	N	S/M	M	M/H	L
	Community Health	With influx of workers, poor sanitation conditions will likely decrease further and there will be opportunity for increased exposure to communicable diseases	N	S/M	M/H	M/H	L
	Community Health	If overcrowded living conditions occur as a result of net influx, incidence of respiratory diseases (e.g. tuberculosis) may increase	N	S/M	M/H	M/H	M/H
	Community Road Safety	Injuries/fatalities due to traffic accidents	N	S/M	M	M/H	L
	Infrastructure and Equipment Design and Safety	The standard of Project design and construction methods influences the reliability of equipment safety, probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	N	S/M	L	M/H	L
	Hazardous Materials Management and Safety	Standards of management of hazardous materials transported to, and handled on, the Project site influences the probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	(N)	S/M	L	M/H	L

	Emergency Preparedness and Response	Any serious medical event or chemical release would constitute an emergency and require an appropriate and prepared response. Emergency planning by Perseus will potentially positively affect the capacity for emergency preparedness and response locally for the duration of the Project life	P	S/M	L	L	L
	Community Security	Social cohesion may be reduced and violence may increase as a result of influx, especially ex-combatants and ex-military, and tension may arise between in-migrants and established residents. Potential for sexual violence.	N	S/M	M	H	M
Operations	Community Health	Increase in communicable diseases including STDs due to the influx of people into the region	N	L	L	M/H	M
	Community Health	Increase in vector-borne disease due to stagnant water	N	L	M	M/H	L
	Community Health	Improvement of health status and wellbeing in community, especially among workers	P	L	H	M/H	M
	Community Health	Lifestyle changes such as consumption of alcohol, tobacco use, drug use leading to health problems (e.g., cardiovascular diseases)	N	L	L	M/H	M
	Community Health	Pressure on health infrastructure due to influx of workers	N	L	M	M/H	M
	Community Health	Access to clean water will effectively be reduced influx of workers	N	L	L	M/H	M
	Community Health	With influx of workers, poor sanitation conditions will likely decrease further and there will be opportunity for increased exposure to communicable diseases	N	L	M	M/H	M
	Community Health	If overcrowded living conditions occur as a result of net influx, incidence of respiratory diseases (e.g. tuberculosis) may increase	N	L	M	M/H	M
	Community Road Safety	Injuries/fatalities due to traffic accidents	N	L	M	M/H	L
	Infrastructure and Equipment Design and Safety	The standard of Project design and construction methods influences the reliability of equipment safety, probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	N	L	M	M/H	L
	Hazardous Materials Management and Safety	Standards of management of hazardous materials transported to, and handled on, the Project site influences the probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	(N)	S/M	M	M/H	L

	Emergency Preparedness and Response	Any serious medical event or chemical release would constitute an emergency and require an appropriate and prepared response. Emergency planning by Perseus will potentially positively affect the capacity for emergency preparedness and response locally for the duration of the Project life	P	L	L	M	L
	Community Security	Social cohesion may be reduced and violence may increase as a result of influx, especially ex-combatants and ex-military, and tension may arise between in-migrants and established residents. Potential for sexual violence.	N	M	L	M	L
Closure	Community Health	Net loss of income due to retrenchment would negatively impact health and wellbeing	(N)	S/M	H	M/H	M
	Community Road Safety	Injuries/fatalities due to traffic accidents	N	S	M	M/H	L
	Infrastructure and Equipment Design and Safety	The standard of Project design and construction methods influences the reliability of equipment safety, probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	N	S	L	M/H	L
	Hazardous Materials Management and Safety	Standards of management of hazardous materials transported to, and handled on, the Project site influences the probability of accidents and pollution spills and emergencies and thereby affects worker and community safety	(N)	S/M	L	M/H	L
	Emergency Preparedness and Response	Any serious medical event or chemical release would constitute an emergency and require an appropriate and prepared response. Emergency planning by Perseus will potentially positively affect the capacity for emergency preparedness and response locally for the duration of the Project life	P	S/M	L	L	L
	Community Security	Social cohesion may be reduced and violence may increase as a result of retrenchments and job losses.	N	S/M	M	M	L/M

9 EMERGENCY PREPAREDNESS AND RESPONSE

Perseus is committed to prevent emergencies that could impact on human health and life, the environment or property. Should an emergency happen, despite all reasonable precautions taken, Perseus has the necessary resources and procedures in place to mitigate the consequences. **Error! Reference source not found.** contains the Internal Emergency Preparedness and Response Management Plan.

Major elements of the mining and process infrastructure relevant in the context of emergency planning include explosives for blasting operations, the cyanide process circuit, hazardous reagents, geotechnical slope failures, rock/mud slides, and failure of the TSF.

The approach of Perseus to the prevention of, and response to, emergency situations is described in the Emergency Preparedness and Response Plan (**Error! Reference source not found.**). The management system can be summarised as follows:

- Perseus will develop a suite of SOPs, training materials, emergency response log sheets and other records as part of the emergency preparedness and response management system;
- Perseus has primary responsibility for ensuring safety of the operations and formulating and applying safety management procedures, as well as utilising technology and management systems to improve safety and reduce risks;
- Perseus will only employ competent personnel in the planning, design, construction, operation/management, closure of the operations and the relevant competences are described in the operating and management plan;
- Perseus will follow all legal requirements of Côte d'Ivoire and international best practice, including the provisions of the International Cyanide Code of ICMI where possible Perseus will operate the Project in accordance with the construction, safety and environmental norms of Côte d'Ivoire and on the basis of an operating and management plan (operation manual) evaluated and accepted by the relevant competent authority, as appropriate;
- Perseus will operate the Project based on relevant operating and management plans (Operating Manuals) that are available to all personnel, local inhabitants, government inspectors and other relevant stakeholders;
- Perseus will seek to establish long-term relationships with stakeholders;
- Perseus will support authorities and local communities in preparing external emergency plans, which will complement the Internal Plan that is part of Perseus's ESMS;
- Perseus will train its personnel reinforce and revise personnel's knowledge on safety and in particular on how to identify potentially harmful events;

- Perseus will operate a system of regular, scheduled inspections and preventive maintenance to ensure that the likelihood and severity of accidents is minimised;
- Perseus will carry out regularly scheduled emergency drills;
- Perseus will implement environmental audits for their facilities and promote use of environmental management systems;
- Perseus will notify competent authorities in case of emergencies that have occurred on the site;
- Perseus will establish incident reporting mechanisms. Perseus has a comprehensive system of incident investigation and documentation in place that enables Perseus to learn from incidents and continuously improve the safety of its operations;
- Perseus will have the necessary human, organisational and technical resources in place to effectively implement the provisions of the Emergency Preparedness and Response Plan; and
- Perseus considers the following Key Performance Indicators important to determine the efficiency of the Emergency Preparedness and Response.

Table 9-1 Key performance indicators - Emergency Preparedness and Response

KPI	Target and threshold	Verification period
KPI 1: Non-observance of provisions in the Emergency Preparedness and Response Plan	Target: Zero	Monthly
KPI 2: Injuries	Target: Zero	Annually
KPI 3: Environmental damage and pollution due to accidental releases	Target: Zero	Annually

Apart from the internal emergency planning of Perseus, an external plan will be developed in collaboration with the communities and competent authorities.

10 CUMULATIVE IMPACTS AND ASSOCIATED FACILITIES

10.1 Overview

In accordance with IFC Performance Standard 1, cumulative impacts must be considered, i.e., impacts that result from the incremental impact, on areas or resources used or directly impacted by the Project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted. Cumulative impacts are limited to those impacts generally recognised as important on the basis of scientific concerns and/or concerns from Affected Communities. Where relevant, the identification of risks and impacts should also consider the role and capacity of third parties.

The habitat of the Project area is highly degraded, harbouring a low wildlife diversity and density. This is a consequence of a high human population density, which translates into a high prevalence of anthropogenic activities, such as deforestation for agriculture purposes, and artisanal mining. More recently, a bigger threat has come from illegal mining activities conducted by Chinese immigrants in the area on a significant scale. Their activities have already impacted this area, with the destruction of riverine forests leading to heavy siltation of the Bandama River in the portion between the hydroelectric dam and the bridge at Bozi on the national road. These activities have led to poor water quality within the Project area and further impacts on the freshwater ecosystem are caused by the hydroelectric Kossou dam, by influencing water flow of the Bandama River.

It is likely that agricultural and artisanal mining activities (see Section 10.2) will continue in the area, as they were identified as the two main economic sectors, which will sustain anthropogenic pressure on the habitat present within the Project area. The proposed mining activities, combined to current anthropogenic activities, will likely exacerbate threats to an already fragile ecosystem.

To the best knowledge of the ESIA contractor, cumulative impacts other than those resulting from agriculture and artisanal mining are not to be expected in the foreseeable future. This conclusion is based on information received from Perseus and the lack of any hints to planned developments during stakeholder consultation meetings.

IFC PS 1 also requires consideration of associated facilities[11]. There are no impacts resulting from associated facilities other than those assessed in this Report (re-alignment of the overhead power line in the TSF area, re-alignment of the Angovia-Kouakougnanou road).

10.2 Cumulative impacts related to artisanal mining

The Study area has been subject to mining exploitation for over a century. However, mining activities have only recently intensified. Industrial exploitation of the mine started in the 1980's and endured with some interruptions for over 30 years (see Section 3.1).

The proliferation of artisanal mining and semi-industrial sites and the influx of foreigners (from the ECOWAS region or China) only happened in the last few years. An estimated presence of

[11] Facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable. Examples in (IFC PS 1, Point 7).

roughly 100 mining sites (2014 survey) in the study area and the presence of over 2,000 temporary foreign workers influences significantly the socio-economic profile of the study area, and the associated socio-economic impacts. Their impact on the biophysical and social environment, that is partly significant in terms of existing pollution and degradation of ecosystems, has been considered in the pre-Project baseline described in Section 0.

Recently, Government intervention has reduced the number of illegal miners in the area, which is expected to lead to a lower environmental and social impact from artisanal mining. However, if artisanal mining activities will increase again in the future, the following cumulative impacts may occur:

- Pollution of surface water (mainly suspended solids, potentially also cyanide and mercury);
- Degradation and erosion of soils, especially on and around artisanal mining pits;
- Degradation of habitats and threat of vulnerable/endangered species due to uncontrolled clearance of land and lack of management/mitigation measures;
- Increased pressure on ecosystem services, especially provisioning (bushmeat, fish, firewood), regulating (dust and erosion protection due to clearance of vegetation/forest);
- Visual and landscape disturbance from unregulated digging and clearance of vegetation;
- Population and Community Change Impacts, especially increase in pressure on social facilities, housing, infrastructure, and government services, potential conflict between locals and outsiders and poor labour conditions; and
- Community health and safety, especially violence.

11 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

11.1 Environmental and Social Management System

Informed by its overall EHS Policy, Perseus will operate an Environmental and Social Management and Monitoring System (ESMS) that consists of various Management Plans covering the following areas of biophysical and social impacts:

- Water Management and Monitoring Plan;
- Soil Management and Monitoring Plan;
- Air quality Management and Monitoring Plan;
- Noise and Vibration Management and Monitoring Plan;
- Extractive Waste Management Plan;
- Biodiversity Management and Monitoring Plan;
- Stakeholder Engagement Plan;
- Social Management and Monitoring Plan;
- Framework Livelihood Restoration Plan;
- Closure and Rehabilitation Management Plan;
- Emergency Preparedness and Response Plan;
- Community Health and Safety Plan; and
- Cultural Heritage Management Plan (Chance Find Procedure).

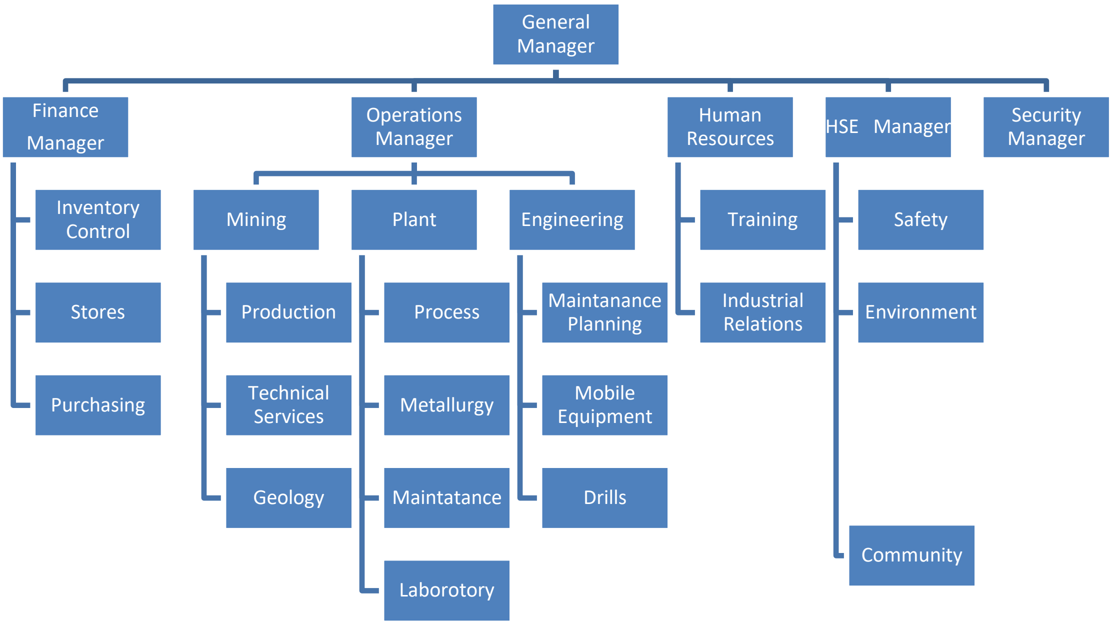
These Plans are attached to the ESIA Report as Appendices (see list starting from page 647). Collectively, they form the ESMS.

Apart from these plans, Perseus will have a comprehensive set of Policies (e.g., Environmental Policy), Management Plans (e.g., Occupational Health and Safety Management Plan), Standard Operating Procedures and Work Instructions in place.

11.2 Organisation and Management Structure

The following figure shows the tentative organisational structure of Perseus's Yaoure Project.

Figure 11-1 Tentative organisational structure of the Yaoure Project



11.3 Waste Management

11.3.1 Waste Streams

Waste associated with Yaouré can be divided into two main types of waste streams:

- Mine waste which includes waste rock and tailings;
- Process water waste streams; and
- Solid waste generated by the operations, consisting of general and hazardous wastes.

The following waste generated by Yaouré is considered:

11.3.1.1 Mine Waste

Geochemical sampling and testing was done on samples of the waste rock, construction material and tailings. The results of the test work indicated the following:

- *Waste rock:* 76 representative samples were taken to determine the Acid Base Accounting (ABA) and Net Acid Generation (NAG) potential. ABA and NAG provide evidence of the likelihood of acid mine drainage occurring. Although the waste rock contains sulphides, 59% of the samples had a content of less than 0.1% sulphide. Only two samples were considered potentially acid generating. The results from the ABA and NAG tests and additional X-Ray Fluorescence (XRF), X-Ray Diffraction (XRD) including Rietveld analysis and short-term leaching using the US EPA Synthetic Precipitation Leaching Procedure (SPLP) were considered. XRF trace element results indicated that there are some elements of potential concern in terms of metal leachability, having concentrations significantly higher than average. The mineralogical characterisation confirmed the ABA / NAG results, with some samples containing sufficient calcite to maintain a neutral pH and others with little sulphide content and therefore limited driving force for acid generation. Based on the short term leaching results, metal leachability is not expected to be a significant issue. The mine will generate a total of 137Mt of waste rock, which will be disposed on one waste rock dump (WRD);

- *Waste rock to be used as construction material*: A total of 23 samples were taken of proposed construction material. These samples were subjected to total sulphur analysis through LECO and XRF trace element analysis. The samples indicated higher total sulphur contents of 0.1% and 0.2%. From these samples alone it was not possible to conclude if acid rock drainage (ARD) will result from construction material. Additional testing before construction commences is recommended.

11.3.1.2 Mine Process Water

Various process water streams will be generated at Yaouré:

Various process water streams will be generated at Yaouré:

- *Return Water Dam (RWD) at the Tailings Storage Facility (TSF):* Water from the slurry will be contained on the TSF. Water, which does not evaporate, will be recycled and reused in process.
- *In-pit Water:* The water from the pits will initially be used in the process. This water will be analysed as per the site Monitoring Plan to check for contaminants before being released into the environment.
- *Water Settling Lagoon:* Run-off will move through a silt trap where all silts will be captured and from where the water will be released into environment. This water will be analysed as per the site Monitoring Plan to check for contaminants before being released into the environment.
- *Run off channels:* Potential leachate may be associated with the derivation channels.
- *Pollution Control Dams (PCDs) at Plant:* The PCD will be lined.
- *Process Water Dam:* All process water dams will be lined and the water reused in the process.
- *Sewage Treatment (for the treatment of wastewater):* Sewage effluent will be treated by methods determined during the DFS. The treatment facilities will be designed to minimise any impact on surface and groundwater quality. The capacity of the treatment facility/s will be sufficient to handle effluent from 300 workers and 100 personnel at the permanent camp. The required limits which treated effluent has to comply with in terms of the World Bank Group (WBG) Environmental, Health and Safety Guidelines: Mining, 2007 are included in Table 11-1. In addition the current limits issued by the Centre Ivoirien Anti-pollution (Anti-pollution Centre Côte d'Ivoire - CIAPOL) which the current operation has to comply with are also provided in Table 11-1. Due to the fact that the processes and the size of the operation associated with the Yaouré expansion will change it might be that CIAPOL will set different limits than the current limits.

Table 11-1 Effluent Water Quality Limits as Stipulated in the Environmental, Health and Safety Guidelines for Mining (Source: World Bank Group, 2007) and CIAPOL

Elements	World Bank Group (WBG) IFC Standards	CIAPOL

	Units	Guideline Values	Units	Limits
Total Suspended Solids (TSS)	mg/L	50	mg/L	50 mg/l if the discharge load exceeds 15 kg/day, otherwise 150 mg/l
pH	S.U.	6 – 9	S.U.	5.5 – 8.5 (9.5) with chemical treatment
Chemical Oxygen Demand (COD)	mg/L	125	mg/L	300 mg/l if the discharge load exceeds 150 kg/d, otherwise 500 mg/l
Biochemical Oxygen Demand (BOD_5)	mg/L	30	mg/L	100 mg/l if the discharge load exceeds 50 kg/d, otherwise 150 mg/l
Oil and Grease	mg/L	10	mg/L	30 mg/l if the discharge load exceeds 5 kg/d, otherwise 10 mg/l
Arsenic	mg/L	0.1	n.a.	n.a.
Cadmium	mg/L	0.05	n.a.	n.a.
Chrome	n.a	n.a	mg/L	0.5 mg/l if the discharge load exceeds 5 g/day
Chrome (VI)	mg/L	0.1	mg/L	0.1 mg/l if the discharge load exceeds 1 g/day
Copper	mg/L	0.3	mg/L	0.5 mg/l if the discharge load exceeds 5 g/day
Cyanide	mg/L	1	mg/L	0.1 mg/l if the discharge load exceeds 1 g/day
Cyanide Free	mg/L	0.1	n.a.	n.a.
Cyanide Weak Acid Dissociable (WAD)	mg/L	0.5	n.a.	n.a.
Fluorine compounds (F)	n.a.	n.a.	mg/L	15 mg/l if the discharge load exceeds 150 g/d
Iron (total)	mg/L	2.0	mg/L	5 mg/l if the discharge load exceeds 20 g/day
Lead	mg/L	0.2	mg/L	0.5 mg/l if the discharge load exceeds 5 g/day
Manganese	n.a.	n.a.	mg/L	1 mg/l if the discharge load exceeds 10 g/day
Mercury	mg/L	0.002	n.a.	n.a.
Nickel	mg/L	0.5	mg/L	0.5 mg/l if the discharge load exceeds 5 g/day
Total Nitrogen	mg/L	10.	mg/L	50 mg/l if the discharge load exceeds 100 kg/day
Total Phosphorus	mg/L	2	n.a	n.a
Phenols	mg/L	0.5	n.a.	n.a.
Total Hydrocarbons	n.a.	n.a.	mg/L	10 mg/l if the discharge load exceeds 100 g/day
Zinc	mg/L	0.5	n.a.	n.a.
Temperature	°C	<3 degrees differential	°C	< 40 degrees °C
Total coliforms	mg/L	400	n.a.	n.a.
Note: Metal concentrations represent total metals				

11.3.1.3 Other Waste Streams

Hazardous and non-hazardous waste will be generated by the operation. The exact volumes are not currently available and will have to be confirmed as part of the Definitive Feasibility Study (DFS). The waste types and potential volumes are included in Table 11-2 (hazardous waste) and

Table 11-3 (non-hazardous waste).

Table 11-2 Hazardous Waste Streams and Approximate, Anticipated Volumes

Waste Type	Potential Volume
Oil Separator (used hydrocarbons and contaminated water)	To be confirmed during the construction and operational phase
Used tyres	To be confirmed during the construction and operational phase
Medical waste	To be confirmed during the construction and operational phase
Old vehicle batteries (containing lead)	Approximate volume expected is 20 per annum from mine equipment (trucks, shovels etc) 10 per annum from light vehicles. These quantities will be confirmed during the operational phase.
Fluorescent tubes	To be determined during the construction and operational phase
Spent oils/ hydraulic oils/ grease and other hydro-carbons	Approximate volume anticipated is 24,000l per annum (2,000l per month) To be confirmed during the operational phase.
Oil filters and rags	To be confirmed during the construction and operational phases
Paint tins containing lead	To be determined
Water of the mill sump at the process plant	Will determine on the time of the year and associated rainfall
Cyanide from the cyanide sump at the cyanide holding tanks	Spillages not foreseen. The sump is only for emergency incidents in the unlikely event that a spill occurs
Transformer oils from the substation	To be confirmed during the operational phase
Workshop sump water	Will determine on the time of the year and associated rainfall. To be determined during the operational phase.
Waste from the Sewage Treatment Facility/s	To be determined during the DFS

It is important that a record of all waste streams be kept as part of a waste register and that it be incorporated into the overall Environmental Management System (EMS) for the Project.

Table 11-3 Non-hazardous Waste Streams

Waste Type	Potential Volume
Domestic waste from the permanent camp and operation	To be confirmed during the construction and operational phase
Salvage yard scrap metals (non-hazardous industrial waste)	Quantities to be determined during the construction and operational phases
General waste e.g. glass bottles, cans, paper, tins	To be determined during the construction and operational

cans, plastic bags, etc.	phases
Biodegradable waste e.g. waste food, grass cuttings etc	To be confirmed during the construction and operational phase. The capacity of the compost site will be designed accordingly.
Non-hazardous containers e.g. water bottles, containers in which food arrives etc.	Quantities to be determined during the construction and operational phases

11.3.2 Waste Management

The waste management requirements for the various waste streams outlined in Section 11.3.1, Table 11-2 and

Table 11-3 are included in Table 11-4. This Table provides the following:

- Specific management measures required for the various types of waste streams;
- Monitoring requirements;
- Specific transportation requirements where applicable;
- Disposal measures required for the safe disposal of the various waste streams, including medical waste and empty cyanide containers; and
- The requirements for the operation of the small approved on-site incinerator is included in Table 5-5.

The management measures are in line with the legal requirements stipulated in the Environmental Code (Act No. 96-766 of October 3, 1996).

It is proposed that the management plan be updated over time as the waste streams or the results from the monitoring change to ensure the protection of the environment.

The waste management measures and requirements included in Table 11-4 are based in the best practice waste management hierarchy including:

- Avoiding the generation of waste where possible;
- Recycling and re-use of waste streams where waste avoidance is not possible, including the separation of waste at source;
- Safe and responsible disposal of waste that adheres to the cradle-to-grave principle.

The waste management measures make provision for the total life cycle of the operation from construction and operation through to the closure phase.

Table 11-4 Waste Management and Monitoring Requirements

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
Mine Waste Streams					
Waste Rock	*Construction Phase*: • Site clearance can lead to increased silt loads into surface water resources • Erosion as a result of run-off over cleared areas	• The necessary clean and dirty water cut-off trenches have to be constructed before site clearance commences • Stormwater management measures to capture silt loads, including silt traps will be installed on the downstream side of the WRD • Clearance needs to be phased as the need for a WRD becomes required • Topsoil will be stockpiled in non-sensitive areas next to the WRD for reuse during Closure • Employ dust suppression measures • Revegetation of earthworks to minimize erosion	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Monthly air quality monitoring for SO_x, NO_x. PM_{10}. $PM_{2.5}$ and fugitive dust fallout • Inspections and cleaning of the dirty water trenches and silt traps during the dry months • Potential erosion and erosion management measures	• Construction Manager • Construction SHEQ Manager • Yaouré Environmental Officer	• No deterioration in surface water quality • Erosion is successfully managed
	Operational Phase • Acid rock drainage (ARD) • Contamination of surface-and groundwater resources	• Additional waste rock classification during the DFS to ensure that the ARD generating waste rock is delineated and disposed of appropriately and managed separately and/or encapsulated • Ensure that clean water is diverted around WRD • The run-off from cut-off trenches will be captured in a downstream silt trap to remove excess silts before discharged into the environment • Silt traps need to be inspected and cleaned on a regular basis • All dirty water has to be filtered through the silt traps • Potential ARD generating waste rock will be disposed in a suitable location and manner to avoid any leachate of ARD generating material • Progressive rehabilitation of WRDs and other earthworks to minimize erosion	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Regular update of groundwater contamination model to determine if there is a risk for a contamination plume and migration • Trend analysis of surface-and groundwater monitoring results to identify any potential contamination risks • Regular inspections and cleaning of the dirty water trenches and silt traps during the dry season	• Environmental Officer • Mine/ General Manager	• Surface-and groundwater limits as set by CIAPOL • CIAPOL and WBG limits, whichever is the stringent should not be exceeded • Containment of any potential pollution plume
	Closure and Post-closure: • ARD • Contamination of groundwater	• Cover potentially acid generating (PAG) material with adequate cover to avoid water and oxygen flow and hence ARD generation • An even soil or oxide layer of between 0.25-0.3 m will be placed on the surfaces of the WRD • It is not sure that topsoil will be sufficient for rehabilitation, so oxydised material may be used for cover gaps • Placement of silt fences or additional erosion control if deemed necessary • Two year aftercare and maintenance plan • Maintain silt traps until the surface-and groundwater monitoring results indicate that there is no deterioration in water qualities	• Two year aftercare and maintenance • Clearing of seepage and drainage channels • Continued surface-and groundwater monitoring as per site Monitoring Plan	• Operations Manager • Environmental Officer	• Water quality limits are not exceeded • WRDs are stabilized and don't hold erosion or safety threats
Construction Material	*Construction Phase:* • ARD	• Additional geochemistry sampling of construction material for potential ARD leachability, if required	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant	• Mine/ General Manager • Environmental Officer	• Benign geochemistry results • Use of non-ARD generating construction material

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
			• Monthly air quality monitoring for SO_x, NO_x. PM_{10}. $PM_{2.5}$ and fugitive dust fallout throughout the life of mine (LoM)		
	Construction Phase • ARD • Contamination of surface-and groundwater resources	• Inert waste rock will be used in the mine construction process	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevantTrend analysis of water quality results to ensure that potential contamination issues are identified timely • Monthly air quality monitoring for SO_x, NO_x. PM_{10}. $PM_{2.5}$ and fugitive dust throughout the LoM	• Environmental Officer • Mine/ General Manager	• Surface-and groundwater limits will be set by CIAPOL • CIAPOL and WBG limits, whichever is the stringent should not be exceeded
	Closure and Post-closure Phase	• Removal of infrastructure not to be handed to Government or communities • Classification of closure waste • Safe disposal of closure waste according to the outcome of the waste classification	• Two year aftercare and maintenance • Continued surface-and groundwater monitoring as per site Monitoring Plan	• Main Contractor • Mine Manager • Environmental Officer	• No deterioration in surface-and groundwater quality • Safe disposal of waste
Tailings Management Facility (TSF)	*Construction Phase* • Vegetation and habitat loss • ARD, arsenic and leachate from TSF • Erosion and siltation	• Demarcate and limit vegetation clearance to actual footprint area • Further tests on the tailings will be required as part of the DFS to determine the most suitable TSF design. • The TSF to be designed in line with the relevant international standards for tailings dam design, construction and operation. • Identify cyanide management and destruction options to reduce cyanide levels to below 50mg/L WAD. • Vegetation clearance may be phased • Topsoil will be stockpiled in non-sensitive areas for use in rehabilitation as and where required for the Project. • Phase the construction of the TSF not to expose soil areas unnecessarily • Implement dust suppression measures	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Trend analysis of water quality results to ensure that potential contamination issues are identified timely • Monthly air quality monitoring for SO_x, NO_x. PM_{10}. $PM_{2.5}$ and fugitive dust throughout the LoM	• Main TSF Contractor • Mine/ General Manager • Contractor SHEQ overseen by Yaouré Environmental Officer	• Potential leachate issues are identified • Proposed cyanide management will endeavor to ensure that cyanide levels are below 50mg/L WAD
	Operational Phase: • ARD leachate • Potential leachate of arsenic from the initial oxide tailings • Contamination of the drinking water resources of the villages • Impacts on surface water resources and the aquatic resources • Impacts on health of communities • Seepage from the TSF can lead to contamination of soil resources	• Regular update of the groundwater model to determine if there is a risk for a contamination plume to form. • Trend analysis of groundwater monitoring results • Ensure that seepage collection trenches are cleaned up on a regular basis • A HDPE lined sump to be constructed to capture the seepage from the trenches. • The sump will be cleaned from fines on a regular basis • Water should be reused in the process • Divert clean water away from the TSF • Should the monitoring results indicated that the cyanide levels in the TSF pond are too high, cyanide destruction will need to be considered •	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Regular aquatic biomonitoring in up-and downstream monitoring points • Toxicity sampling should sediments accumulate in down streams points on a bi-annual basis • Regular update of groundwater contamination	Environmental Officer Mine/ General Manager	• Acceptable ABA, NAG, XRF, XRD and SPLP results from additional test work. • Formation and migration of a pollution plume will not threaten natural or community water resources • Clean sump and seepage collection trenches

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
			model to determine if there is a risk for a contamination plume and migration • Trend analysis of water quality results to ensure that potential contamination issues are identified timely • Regular inspection and cleaning of the sump and seepage collection trenches		
	Closure Phase: • Formation of a pollution plume to negatively impact groundwater • Erosion of the TSF can lead to siltation and arsenic in the surface water • Negative impacts on human health, livestock and aquatic biodiversity	• Concurrent rehabilitation of the TSF • Conduct vegetation trials on the TSF prior to closure to identify the most appropriate option • The most appropriate closure option for the TSF based on relevant scientific data and good industry practice. • Dismantling and removal of the tailings delivery lines, pump station etc. • The tailings pipeline will be flushed onto the TSF to remove any tailings • The pipeline corridor will be rehabilitated. • Long term stabilization of the TSF • Retain seepage collection pond until such time that the water quality does not show any impact • Rehabilitating access roads, ponds, collection channels and berms • All access roads to the TSF to be removed after the two year after care and maintenance and access restricted to avoid any activities on the TSF	• Two year aftercare and maintenance • Surface-and groundwater monitoring as per site Monitoring Plan • Aquatic biomonitoring, including toxicity monitoring as per site Monitoring Plan • Annual post-closure monitoring of the TSF • Monitor revegetation and rehabilitation	Company Environmental Officer	• Water quality returns to pre-mining qualities • No seepage or erosion from the TSF • Revegetation of at least 75% achieved
Return Water Dam (RWD)	*Operational and Closure Phase* • Contamination of surface and groundwater resources • Negative impacts on the aquatic life • Negative impacts on birds and terrestrial fauna coming into contact with cyanide on the RWD water • Potential contamination of community drinking water resources • Potential impacts on aquatic biodiversity	• Destruction of cyanide at the plant will be considered as part of the DFS, based on expected cyanide levels in the tailings • Re-use of RWD water in the process • Treatment of water to applicable standards before release into the environment	• Ensure that sufficient surface-and groundwater monitoring points are in place • Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Trend analysis of available historic and resent surface-and groundwater monitoring results • Regular update of the groundwater model to determine if there is a risk for a contamination plume to form.	Environmental Officer and Mine/ General Manager	• CIAPOL and WBG limits, whichever is the stringent should not be exceeded • Formation and migration of a pollution plume will not threaten natural or community water resources
Process Water Dams (PWDs)	*Construction Phase* • Pollution of surface-and groundwater resources • Contamination of soils with cyanide • Potential health impacts to employees and surrounding villagers	• Line all the process water dams • Determine the need to install cut-off trenches downslope of the PWDs • Install monitoring bores in key areas to identify potential groundwater contamination from water storage facilities • The PWDs will be designed to accommodate 1:100 year, 24 hour flood events and will have the necessary freeboard	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Surface water monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Regular inspection and cleaning of the cut-off trenches according to the site maintenance program • Monitoring of the liners of the process water dams	Environmental Officer and Mine/ General Manager	• No deterioration in water quality downstream of the plant • Liner of process water dams are intact • No seepage from the process water dams
	Operational Phase: • Pollution of surface-and groundwater resources • Contamination of soils with cyanide	• No discharge of water from the process water dams into the environment	• Groundwater monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant Surface water	Environmental Officer and Mine/ General Manager	• No deterioration in water quality downstream of the plant • Liner of process water dams are intact

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
	• Potential health impacts to employees and surrounding villagers		monitoring: Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant • Regular inspection and cleaning of the cut-off trenches. Note: the final designs and configuration of the cut-off trenches will only be confirmed during the DFS phase according to final infrastructure and layouts. Monitoring of the liners of the process water dams		• No seepage from the process water dams
	Closure Phase • Contamination of surface-and groundwater • Contamination of soils with cyanide • Potential health impacts to employees and surrounding villagers	• All water in the PWD to be evaporated or treated and released at the time of closure • Peroxide used for cyanide detoxification; peroxide treatment will not add chloride to the discharged stream and is easy to dose and monitor • Remove the liners and place on the TSF or dispose • Maintain clean and dirty water management measures after closure until water quality stabilizes to pre-mining qualities • Rehabilitate PWD areas	• Surface and groundwater monitoring Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant Aftercare and maintenance of clean and dirty water structures until no longer required • Monitor revegetation and rehabilitation	Company Environmental Officer	• Rehabilitation and revegetation of 75% achieved • No impacts on surface and groundwater
Sewage Treatment Systems	*Construction Phase* Loss of vegetation	• Demarcate and limit clearance to footprint areas • Construction of an appropriately designed sewage treatment facility • Secondary containment will be considered for all sewage lines • Sewage Treatment Facility/s will be constructed away from water resources • Regular manual inspections of the integrity of the sewage treatment system and lines	• Monitor construction activities to remain within approved footprint areas only	Main Contractor SHEQ Environmental Officer	• Clearance within footprint areas only
	Operational Phase: • Pollution of groundwater resources • Contamination of drinking water resources of the villages • Bacterial infections as a result of incorrect disposal of sludge	• Regular pumping and cleaning of solids from the facility/s • Regular maintenance and inspection of facility/s to ensure effective functioning • Monitor sewage treatment systems to detect leakage • Avoid use of bleach and grease that could impact on the functioning of the system • Sewage treatment facility/s to be designed to ensure that the treated effluent will not exceed the WHO limits for treated effluent. • Test the sludge/solids to determine the best disposal options, if non-hazardous it can be used for landscaping purposes, if hazardous it can be disposed of on the TSF or existing HLPs	• Leakage detection monitoring of the system on a regular basis • Groundwater monitoring: as per site Monitoring Plan Surface water monitoring: as per site Monitoring Plan • Trend analysis of surface-and groundwater results to detect any contamination timeously and to ensure that additional management measures can be put in place	Environmental Manager and Maintenance Manager	• CIAPOL and WBG limits, whichever is the stringent should not be exceeded
	Closure Phase • Groundwater contamination • Soil contamination	• Remove all sewage lines and dispose of appropriately • Remove the sewage treatment facility infrastructure and dispose with hazardous waste streams, except in the event where it will be retained in agreement with authorities and communities • Remove any contaminated soils or containments and dispose as hazardous waste • Rehabilitate the sewage treatment facility area/s	• Test soil should contamination be expected • Continue surface-and groundwater monitoring programme. Monitoring scope and frequency will be tailored to the requirements and objectives for each location and project phase, so that monitoring remains focussed and relevant	Contractor Environmental Manager	• All hazardous waste disposed safely
In-pit Water	*Construction and Operational Phase:* Potential contamination of surface-and groundwater	• In-pit water will be re-used in the process where possible • Monitoring of in-pit water qualities to determine potential uses • Should in-pit water have to be released into the environment the water quality will not exceed the acceptable WBG or CIAPOL • Where limits are exceeded water will be treated before release • Use of environmentally friendly blasting agents where feasible	• Modelling of the potential draw-down cone will be done on a regular basis • Should pit dewatering lead to impacts on water security of surrounding villages or water users, alternative sources of water will be supplied. • Groundwater levels will be monitored as per site Monitoring Plan and trend analysis of levels will be done	Environmental Manager and Mine/ General Manager	• CIAPOL and WBG limits, whichever is the stringent should not be exceeded • Drawdown cone will stabilize • Water security to the surrounding villages will not decrease
	Closure Phase: • Potential community health and safety impacts • Impacts on terrestrial fauna	• Retain protection bunds installed during operation and block ramp access to pits • No discharge from pit	• Monitor in-pit water to determine a suitable end use • Model potential pollution plume	Closure Contractor CLO and Environmental Officer	• Groundwater quality stable

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
RoM Pad	*Construction Phase:* Potential ARD leachate and associated contamination of groundwater	• Undertake further testing of the RoM Pad material during the DFS phase to confirm the nature of the material, as per the WRDs to inform final design requirements • In the event of the RoM Pad material being inert with no leachability threat, ensure that the RoM Pad has silt traps installed at the base • Clearly demarcate footprint area for clearance and preparation	• Monitor that footprint clearance be done to the smallest footprint area • Monitor the stripping and stockpiling of topsoil, outside of sensitive areas and at a height that will not kill the seedbed • Monitor potential erosion and erosion management measures	Construction Manager Environmental Officer	• Best practice implemented for preparation of RoM pad • No erosion, or contamination form RoM
	Operational Phase: Potential ARD leachate and associated contamination of groundwater	• Maintain berms around the RoM • Ensure that the RoM deposition remain within the designated footprint	• Regular inspection and maintenance of berms and any leachate detection system • Ensure that the current groundwater monitoring programme make provision for the monitoring of groundwater associated with the RoM	Environmental Manager Mine/ General Manager Environmental Officer	• No decrease in groundwater quality associated with RoM
	Closure Phase: • Potential soil contamination • Fugitive dust that can harm humans and flora • Increased silt loads with metals in run-off	• Process all RoM Pad ore and rehabilitate the remaining material as per the WRDs • Test surrounding soils to determine if soil has to be removed and to what depth • Remove potential contaminated soil and place on TSF • Maintain silt traps until revegetation commences to reduce potential erosion • Remove silt traps once revegetation is approximately 75%	• Monitor rehabilitation • Maintain erosion control measures • Continue surface-and groundwater monitoring programme as per site Monitoring Plan	Operations Manager Environmental Officer	• All potential contaminants removed • Acceptable level of rehabilitation
Hazardous Waste Streams					
Oil Separator (used hydrocarbons and contaminated water)	*Construction Phase:* Trenching and site clearance can hold health and safety risks	• Use barricading to protect people and animals from entering unsafe construction areas • Design and construct oil separator and associated drains to accommodate 1:100 year 24 hour flood events • Ensure that workshop floor and drains are sealed (eg. Concrete) • Ensure that oil separator is on a impervious surface and in a bunded area	• Daily inspections • Health, Safety and Environment (HSE) training • Induction training • Construction monitoring	SHEQ Officer Project Manager Construction Manager	No safety incidents
	Operational Phase: Spillages from oil separator system can lead to contamination of groundwater, soil and surface water	• Regular cleaning of drains • Place waste material in clearly marked bins in the hydrocarbon waste storage area • Inspect, clean and service separator regularly • Ensure that spill-kits are available in the event of spillages • Train personnel in the effective management of the system • Ensure that emergency procedures are communicated to personnel and that they are trained in spill clean-up	• Keep a waste register • Monitor the effectiveness of the system • Regular maintenance • Continue water quality monitoring up and downstream of the processing plant and associated infrastructure as part of the overall monitoring programme	Workshop manager Environmental Officer	• No incidents of spillages • Maintenance of effective oil separation system
	Closure Phase: Contamination of soils as a result of the removal of the oil separator system and associated infrastructure	• Remove all hydro-carbons from the oil separator and return to supplier of oils and diesels • Remove all contaminated infrastructure and dispose of appropriately • Trained personnel to undertake rehabilitation • Rehabilitate the area	• Visual monitoring of soil for any contaminants • Soil sampling should contaminants be evident	Environmental Officer	No contamination or spillages
Used tires	*Construction, Operational and Closure Phase:* Non-biodegradable accumulation of waste	• Construct a storage area for the temporary storage of waste tyres • Suppliers to collect tires for recycling • Waste tyres not to be burned	• Keep a waste register • Monitor storage area and arrange for removal of tires once storage area is full	Workshop manager Environmental Officer	No tyres outside tyre storage bay, other than those used for traffic management purposes All tyres recycled where possible
Medical waste	*Construction, Operational and Closure Phase:* Bacteriological and viral contamination and infections	• Medical waste will be incinerated using an appropriate incinerator • The incinerator will be operated and maintained in line with manufacturer's instructions • Appropriate buffer zone to be maintained around any industrial incinerator	Included under Section 11.3.5	Waste Manager Environmental Officer	Maintenance and emission requirements included in Section 11.3.5 are achieved
Old vehicle batteries (containing lead)	*Construction, Phase:* Lead contamination	• Construct hazardous waste collection and temporary storage bays with impervious floors • Ensure that storage areas have secondary containment and roofed • The storage areas should be provided with lockable emergency valves should pollutants	• Monitor construction to be in line with best practice design	Construction manager	Suitable storage areas provided

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
and paint tins containing lead	Negative impact on human health	have to be drained from the storage areas • Separate storage bays should be provided for separate waste streams, where possible			
	Operational Phase: Lead contamination Negative impact on human health	• Suppliers to collect batteries • Waste register to be updated • Ensure that the necessary firefighting equipment is put in place • Ensure that waste disposal certificates are obtained	• Monitor the storage bays for any spillages • Spills need to be cleaned up immediately	Environmental Officer	• Separation of hazardous waste streams • Control of potential spillages
	Closure Phase: Lead contamination Negative impact on human health	• Remove all hazardous waste storage bays • Undertake a risk assessment in terms of potential contamination • Should liners/ cement be contaminated this needs to be disposed of as hazardous waste • Sufficient cover to avoid surface water run-off should be provided	• Soil sampling should contamination be expected • Monitor disposal of waste streams	• Operations Manager • Contractor	• Risk to the environment eliminated
Fluorescent tubes	*Construction Phase:* • Mercury contamination • Human health impacts	• A designated storage area will be identified for the storage of fluorescent tubes. • Fluorescent tubes will be collected by the relevant suppliers, where possible • Awareness training in terms of overall waste management and specifically also handling and disposal of fluorescent tubes	• Oversee the construction of the hazardous storage areas and bays	• Construction Manager • Project Manager	• Hazardous storage area designed and constructed according WBG Health and Safety Guidelines for Mining, 2007
	Operational Phase: • Mercury contamination • Human health impacts	• A designated storage area will be identified for the storage of fluorescent tubes. • Fluorescent tubes will be collected by the relevant suppliers, where possible • Awareness training in terms of overall waste management and specifically also handling and disposal of fluorescent tubes	• Capture fluorescent tubes in waste register • Keep disposal certificate record	• Waste Manager • Environmental Manager • Maintenance Manager	• Correct disposal of fluorescent tubes • No risk to human health or the environment
	Closure Phase: • Soil contamination	• Removal of all fluorescent tubes • Undertake a risk assessment in terms of potential contamination • Should liners/ cement be contaminated this needs to be disposed of as hazardous waste • Sufficient cover to avoid surface water run-off should be provided	• Soil sampling where the risk of soil contamination has been identified • Monitor safe disposal waste streams	• Operations Manager • Contractor	• No legacy contamination risks
Spent oils/ hydraulic oils/ grease and other hydro-carbons/ oil filters/ oil contaminated rags	*Construction Phase:* Contamination of surface- and groundwater and soils	• Workshops buildings will be bunded • Sumps will be constructed at workshops to capture hydrocarbon spillages • All workshop floors will consist of impervious surfaces • A cut-off drain will be constructed at the entrance of workshops to ensure that potential spillages are captured and relayed to an oil separator system • A separate storage bay will be constructed for the storage of spent hydrocarbons • The storage area will be a roofed and bunded with an impervious surface with a sump from which potential spillages can be drained	• Oversee the construction of the hazardous storage areas and bays	• Construction Manager • Project Manager	Hazardous storage area designed and constructed according WBG Health and Safety Guidelines for Mining, 2007
	Operational Phase:	• Capture all hydrocarbons • Separate storage containers for the various waste types • Containers to be marked according to international requirements • Arrange that spent hydrocarbons and waste be taken back by the suppliers or by registered recycling agents and disposal certificates obtained • Rags to be disposed as hazardous waste • Any spillages will be cleaned up immediately • No other material will be stored in the bunded hydrocarbon area • Drip trays will be emptied into the relevant containers • Cleaning water will be captured and relayed to the oil separator • Spill kits will be made available • Awareness training on separation of waste and management of spillages will be given to all personnel	• Monitor and clean storage area on a regular basis • Include waste quantities in the waste register • Capture spillages and incidents • Monitor the close out of incidents	Workshop Manager Environmental Manager All Personnel	Risk of hydrocarbon contamination is understood and managed
	Closure Phase: Soil contamination	• Removal of all hydrocarbons by the suppliers • Undertake risk assessment to assess the potential of soil contamination • Removal of hydrocarbon storage bay • Dispose as hazardous waste	• Monitor to ensure safe disposal of material	Operational Manager Contractor	Risk of contamination understood and eliminated
• Water of the mill sump at the process plant	*Construction Phase:* • Site clearance lead to erosion • Habitat destruction	• Restrict footprint clearance to the smallest possible size • Strip and stockpile topsoil (during dry season) • Ensure areas under the mill and cyanide holding tanks are sealed to avoid surface and groundwater contamination	• Monitor site clearance and topsoil stockpiling • Monitor construction activities to remain within footprints	Construction Manager Project Manager	• Risk of operational phase spillage reduced • Clearance managed • Topsoil stripping and

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
• Cyanide from the cyanide sump at the cyanide holding tanks		• Size sumps to contain any likely spillage or overflow events		Environmental Manager	stockpiling in accordance with the Soil Management Plan (Appendix 24 of the ESIA)
	Operational Phase: • Contamination of surface and groundwater • Soil contamination • Impacts on human health and terrestrial and aquatic fauna	• Maintain capacity of sumps through regular cleaning • Use water from the sump in the process • No discharge of water into the environment • Regular clearance of the sumps.	• Continued Surface-and groundwater monitoring	Environmental Officer	Protection of the natural water resources No spillages from sumps
	Closure Phase: • Cyanide contamination of groundwater, surface water and soil • Potential health impacts • Negative impacts on aquatic and terrestrial biodiversity	• Peroxide will be used for cyanide detoxification; peroxide is preferred because it is easier to dose and monitor, and peroxide treatment will not add chloride to the discharged stream. • Liners will be disposed of appropriately	Monitor water quality form the ponds before discharged	Operations manager Environmental Officer	No substance release which does not comply with CIAPOL standards
Transformer oils from the substation	*Construction and Operational Phase:* Spillage of transformer oil and associated soil contamination	• Transformers will be placed into secondary containments to avoid spillage onto soil • Used transformer oils will be stored in a separate bund in the hazardous storage area as per aforementioned design requirements • Should spills occur they will be cleaned up immediately and rectification actions put in place	• Construction and operational phase monitoring	Project and Construction Manager Maintenance Manager	No spillage of transformer oils
	Closure Phase: Potential soil contamination	• Where transformers will not be kept for community purposes, all fluids need to be drained and removed off site by a licensed contractor • Best end use of disposal for transformers will be assessed closer to closure	• Rehabilitation monitoring	Environmental Officer	No spillage of transformer oils Safe disposal
Workshop sump water	*Construction Phase:*	• Sumps will be constructed in the relevant workshops to capture any hydrocarbons • The sump has to be constructed from an impervious material • Provision for drainage into the oil separator system will be required	• Construction monitoring	Project Manager Construction Manager	Construction according to best practice
	Operational Phase:	• Regular cleaning and annual maintenance to the sump to ensure its integrity is maintained	• Monitor integrity of the sump on an annual basis	Workshop Manager	No risk of leakage from sump
	Closure Phase:	• Empty and clean sump • Disposal of sump water as appropriate • Remove sump with other rubble	• Monitor decommissioning activities	Operations Manager	Correct disposal of waste streams
Hazardous landfill cell	*Construction Phase:*	• The hazardous waste cell will designed in accordance with international best practice requirements, and local environmental requirements • A downstream sump will be constructed to collect run-off from the landfill site	• Ensure that site is constructed in line with international best practice	Project Manager Construction Manager	Provision of a hazardous cell which will protect the environmental from impacts
	Operational Phase:	• Maintain cut-off trench around the landfill site to avoid run-off entering the site • Operate the site in line with international good practice	• Surface-and groundwater monitoring	Environmental Manager	No risk to the environment
	Closure Phase:	• Ensure that the site is closed in line with international best practice For the purposes of the Conceptual Closure Plan, a 50 x 50 m² of the landfill cell has been assumed.	• Two year aftercare and maintenance • Closure monitoring	Operations Manager	Potential risks eliminated
Non-Hazardous Waste Streams					
General non-hazardous waste and general landfill site	*Construction Phase:* • Habitat loss and potential erosion	• Design and construct a general non-hazardous landfill site in accordance with international best practice requirements, and local environmental requirements • The landfill site will be designed and constructed to prevent the contamination of surface and groundwater	• Construction monitoring	Project Manager SHEQ and Environmental Manger	Construction in accordance with international best practice
	Operational Phase: • Littering	• Correct management of landfill site through regular coverage and compaction of newly deposited waste with a soil layer	• Groundwater monitoring according to site monitoring program	Landfill Site Manager	• No deterioration in groundwater quality

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
	• Contamination of groundwater from landfill sites can generally lead to increased levels of TDS, chloride and sulphate • If not properly managed the landfill site can attract rodents and other pests that can carry diseases	• Installation of groundwater monitoring boreholes up-and downstream of the landfill site • Cut-off trenches/berms around the landfill site to avoid additional run-off entering the site • Designated responsible manager for the waste and landfill site	• Surface water monitoring according to site monitoring program • Trend analysis of surface-and groundwater results to detect any contamination timeously and to ensure that additional management measures can be put in place	Environmental Manager Mine/General Manager	associated with the landfill site • Effective pest control
	Closure Phase: Seepage from the landfill site and associated surface-and groundwater contamination		• Closure monitoring	Operations Manager Environmental Manager	• No seepage from landfill site
Domestic waste from the permanent camp and operation	*Construction Phase*:	• Waste water to be pumped to the sewage treatment facility •	• Construction Monitoring	Project Manager SHEQ Officer	• Temporary waste storage and handling area constructed according to best practice
	Operational Phase: Attract pests	• Store waste in bins with lids • Collect and remove waste on a daily basis to the general landfill site • Manage to ensure that no odors are produced	• Record waste collection and disposal volumes	Waste manager Environmental Manager	• No pests • Bins don't overtop • Limited odours
	Closure Phase:	• All wastes generated during closure are to be disposed of appropriately	• Closure and rehabilitation monitoring	Operations Manager Contractor Environmental Manager	• No residual contaminants
Salvage yard scrap metals	• Bad housekeeping • Potential accidents	• All scrap metals to be stored in designated areas • Scrap metals to be collected on a regular basis to maintain good housekeeping and transported to the scrap metal yard • Scrap metals to be recycled	• Record waste collection and disposal volumes	Waste manager Environmental Manager	• Scrap metals stored separately • No scrap metals lying around outside of designated areas
General waste e.g. glass bottles, cans, paper, tins cans, plastic bags, etc.	• Littering • Danger to smaller fauna species	• Separate waste streams at source in different bins • Awareness training of all employees on waste management practices • Recycling of general waste, where possible • Keep waste inventory	Monitor any littering	Waste manager Environmental Manager	Up-to-date waste inventory No littering
Biodegradable waste e.g. waste food, grass cuttings etc.	• Attract pests • Nuisance • Bad odors	• Construct a composting area • Remove waste to the compost heap for use in landscaping	• Run-off from compost heap is controlled • Volume of compost is not exceeding storage capacity	Environmental Manager	Recycling of biodegradable waste for landscaping purposes
General Requirements in terms of Waste Management					
Waste generation	• Potential contamination of soil, surface-and groundwater • Negative impacts on fauna and flora • Negative impacts on human health and safety	• Record and account for the quantities of all waste streams as part of the environmental management system • Implement the waste management hierarchy in terms of waste production where as a first step the generation of waste will be avoided; secondly where it can't be avoided to mininise waste, thirdly to recycle and re-use waste and as final solution to dispose of waste • Obtain waste disposal certificates from all third party waste collectors to ensure that the cradle-to-grave principle is achieved • Ensure that all third-party waste collectors provide proof of licensing, where relevant, in terms of the transportation and disposal of the specific waste streams • All third-party contractors are informed and have to adhere to the Yaouré Gold project waste management requirements	• External audits on waste management practice by CIAPOL • Annual external audits on environmental compliance including waste management practices	Overseen by the Environmental Manager	No non-compliance recordings

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		• Waste packaging and labelling needs to be in compliance with the international requirements for the handling, storage and transportation of waste. • Waste streams will be separated at source and clearly marked in terms of the points above • Awareness training of all employees and contractors on waste management practices			
Transportation of Waste					
The IFC Environmental, Health and Safety Guidelines for Waste Management states the following requirements in terms of the transportation of waste: • Classify the waste streams • Spillages of waste during transportation should be avoided; • All containers to be transported off-site need to be secured and labelled according to the contents and the associated hazards • Hazardous waste need to be transported by licensed contractors • Host-country commitments under the Basil Convention					

11.3.3 Transportation of Waste

The transportation requirements for the various waste streams associated with the Project are included in Table 11-4. For wastes being taken off site for recycling or disposal, the original suppliers or registered contractors will be used where available and collection receipts/disposal certificates will be obtained from those contractors.

11.3.4 Waste Disposal Arrangements

The waste disposal arrangements for the Project are included in Table 11-4. All wastes being disposed of will be recorded in a waste register to allow the amounts of different types of wastes to be identified and tracked.

11.3.5 Medical Waste Treatment

Medical waste will be incinerated either on site, or at a suitable alternative location (eg. Kossou or Yamoussoukro Hospitals). Any incinerator used on site will be operated and maintained in accordance with the manufacturer's specifications and in line with good international practise.

As part of the DFS, the feasibility of having an industrial incinerator for the Yaoure Gold Project will be investigated.

11.4 Water Management

Communities and authorities have expressed concern about the potential impact that the project could have on surface and underground resources. Potential impacts, management measures and the monitoring requirements for the protection of the quality / quantity of surface water and groundwater and the assurance of water security for the surrounding communities are included in Table 11.5.

Table 11-5: Surface and underground water management and monitoring required

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
			Surface water management		
Tailins storage facility, waste dumps, mine pits	Construction phase • The clearance of supermarkets can lead to siltation • The discharge of water into the pit at the start up of mining operation can lead to contamination of surface water and negative impacts related to livestock, human health and aquatic life	• comprehensive waste characterization program • Areas will be cleared as required by step construction • Construction of underground drainage and collection of trench infiltration water and tailings pond systems. • Design all stop trenches upstream of the RAP and the waste rock repository to separate clean water from dirty water and be part of the DFS • Erosion control measures, stormwater control structures, and healthy and unhealthy diversion infrastructure channels will be installed upon clearing if necessary • If necessary, trenches will be constructed along portions of the tip of the waste rock dyke to intercept water that would flow into the tailings deposit area and reduce the risk of erosion of the tip of the dike. . • Appropriate leak detection systems will be installed eg monitoring boreholes, pressure loss detectors, etc.	• Characterization assessments of additional waste before starting construction • Monitor surface water: according to the Site Monitoring Plan • Ensure fingerprint clearance at the smallest impression area • Monitor stripping and storage of topsoil outside sensitive areas and at a height that will not kill the seedbed • Monitor possible measures and erosion management	Construction Manager Project Manager	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO
	Operation phase • Contamination of surface water resources as a result of seepage from RAP and waste rock repository • Health impacts on communities, aquatic wildlife and livestock • RAP failures can impact downstream streams, streams and encampments	protect PAG materials with adequate coverage to prevent ingress of water and oxygen, and ARD generation • sediment traps through which any runoff will be channeled to ensure silt is trapped • No wastewater disposal and treatment • Reuse of runoff wastewater in the process • The Company develops pre-commissioning operational manual that will use the TSF and the waste rock dump. • Ensure that the Emergency Response Plan is	• Monitor surface water: according to the Site Monitoring Plan • Monitor sediment toxicity in downstream streams according to the Site Monitoring Plan • track and maintain stop trenches and seepage collection trenches • Downstream silt traps, diversion trenches, and seepage collection	environmental officer Tailings storage facility and WRM operating engineers The geotechnical engineer	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
		communicated to all employees and communities during regular Community Committee meetings • Stabilization of slopes with goal at closing	channels will be monitored (regularly) and maintained as required. • Ensure impression cleaning is restricted to the smallest fingerprint area • Monitor removal and storage of topsoil, outside sensitive areas and at a height that will not deplete the seedbed • Monitor potential erosions and erosion management measures that could affect surface water quality • Regularly check the geotechnical stability of TSF and waste rock deposits		
	closing phase • *Surface water contamination from TSF runoff and waste rock deposits*	• Concurrent rehabilitation of TSF and waste rock deposits during the operational phase • Final rehabilitation in accordance with the provisions in Table 6-4 • Monitoring over two years of maintenance to ensure structural stability • Maintain barrier trenches and freshwater and wastewater separation system during closure • Peroxide used for the detoxification of cyanide; the peroxide treatment will not add chloride to the flux, and remains easy for dosage and control. • All water coming out of sediment traps must meet the water quality limits set by CIAPOL or WHO (included in Table 6-1). • Remove trench liners once follow-up trend analysis indicates no residual effects. Dispose of materials and liners in accordance with the provisions of Table 6-4	• surface water monitoring - according to the site monitoring plan • monitoring of aquatic biodiversity according to the Monitoring Plan • Toxicity tests - according to the Site Monitoring Plan	• Operations Director • Environmental Officer	the water quality results in accordance with the results before mining

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
Erosion	Construction phase • Erosion of cleared areas leading to increased silt / TSS / turbidity loads in surface water resources	• Vegetation and topsoil will not be removed until construction is completed • Simultaneous rehabilitation throughout the life cycle of the mine • Construct erosion control measures where necessary, including flood mitigation, gabions, rock cladding, berms, etc. • Construct clean and dirty water systems to divert clean water from work preferably before cleaning, if necessary • Construct infiltration collection trenches around the infrastructure, particularly TSF • Construct sediment traps at points downstream of the waste rock dump, TSF, landfil and silt capture vegetation belt • the development of a necessary slope and installation of sediment trap v-drains will be built along the roads to reduce sediment loads	• monitoring of the quality of surface water - according to the monitoring plan of the site • monitoring of aquatic biodiversity - according to the site monitoring plan Regular inspections of the erosion control infrastructure • Maintenance and cleaning of erosion control infrastructure	• Environmental Officer • Maintenance Manager	• Effective control of erosion • No increase in TSS, pH, temperature and TDS of water quality
	Operation phase • *Erosion of cleared areas* • *Increase in silt loads*	• Simultaneous rehabilitation throughout the life cycle of the mine • the maintenance of erosion control measures • Upgrading if necessary erosion control measures • Maintain erosion control measures • Improve erosion control measures if necessary • Regularly check and maintain any drinking water and wastewater systems • Maintain and clean the infiltration water collection trenches of the infrastructure, particularly TSF and waste rock dump • Regular cleaning of sediment traps at points downstream of the waste rock repository, RAP, landfill, and central area to capture the silt load • Elimination of TSF silt • The footprint of the waste rock deposit will be profiled to limit erosion	• settling basins, sediment traps, and drains will need to be inspected and cleaned regularly • erosion protection, erosion control and stormwater infrastructure management will be monitored and maintained as needed	responsible for maintenance . Environment and Supervision Officers	• Effective control of erosion • No increase in silt load / TSS / turbidity reported in surface water monitoring results

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
		• The TSF will be limited and simultaneous rehabilitation (including revegetation) will be done at the same time if possible • Roads will be contoured to minimize water accumulation and erosion structures • Flow with large sediment loads captured in settling ponds to ensure fines are contained			
	Closing phase • Increased exposure and soil erosion during the closure phase following site clearing	• gradual rehabilitation • Backfilling and leveling areas to help with natural revegetation • leveling areas to help restore natural flow patterns • Maintenance of stormwater and erosion control infrastructure until revegetation reaches 75% • Remove rainwater and erosion control structures once the rehabilitation is complete.	Two years of monitoring and maintenance • Continue monitoring of surface water according to the monitoring site plan • Maintenance of stormwater control infrastructures	• Operations Director • rehabilitation specialist • Environmental Officer	Erosion is successfully controled
Runoff or flowing from the plant, work areas, operation (wastewater areas) into the environment	Construction phase • Contamination of surface water by chemicals, hydrocarbons and contaminated sites	Design and construct and treat "wastewater" water containment structures to accommodate 1: 100 year flood, or as calculated during DFS. • Delineation of wastewater areas • Construct clean and wastewater trenches around "wastewater areas" • Construct sediment traps downstream of the plant • Separation and effective containment of dirty water through stormwater management structures	• surface water monitoring: according to the monitoring site plan	Director of Construction SHEQ and environmental officer	• Effective separation of clean and used water • Containment structures that are measured and constructed to contain dirty process water
	Operation phase • Contamination of surface water resources • Potential health impacts on communities and livestock • Potential impacts on aquatic biodiversity	• Contain all processes and "runoff water" and maintain zero discharge • Reuse of water in the process • Maintain all stormwater management infrastructures	• Surface water monitoring: according to the monitoring plan of the site • Annual inspections of containment dam linings • Monitor any infiltrations in the central area	responsible for maintenance Environmental Manager	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO
	closing phase • Contamination of	• Remove all potentially hazardous contaminants from the site	• Two years of monitoring and maintenance	Contractors Director of Operations	All potential contaminants are

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
	surface water that comes into contact with contaminated surfaces during closure	• Unused chemicals and reagents must be properly disposed of (eg returned to suppliers) • Remove all potential contaminated surface infrastructure, including liners, pipelines, etc., and dispose of them • Areas where infrastructure has been removed must be backfilled to prevent erosion and improve rehabilitation	• surface water monitoring according to the Site Monitoring Plan • monitoring of aquatic biodiversity according to the site monitoring plan	/ Mine environmental officer	safely disposed of in accordance with best practices
Cyanide spills from the storage area, treatment ponds or infiltration of water treatment dams	Construction phase • possible siltation and impact on surface water quality	• stagger the cleaning and construction of the site • Undertake simultaneous rehabilitation • develop storage areas according to best practices, cyanide, for example, will be stored separately with an impervious base and a reservoir to capture potential spills • Build an emergency flow tank that can hold 110% for the largest capacity • Design of treatment water storage facilities to withstand 1: 100 years 24 hours of weather • Install leak detection systems where appropriate • Construct all treatment ponds with a liner and ensure that the supply ducts have secondary containment • process ponds will have controlled access	• Regularly monitor the integrity of storage areas • Inspect liners on an annual basis • monitor surface water downstream of the plant according to the site monitoring plan • monitor daily pond levels according to the site control plan	Plant manager environmental officer	• No leakage from treatment ponds • No spills of cyanide or process water
	Operation phase • Contamination of surface water resources • Potential health impacts on communities and livestock • Potential impacts on aquatic biodiversity	strive to comply with international standards for the storage and handling of cyanide • Cyanide will be stored separately with an impervious base and a tank to capture potential spills • All water will be reused, it will not be released into the environment • An emergency and incident response plan to deal with everything dumping	• surface water monitoring upstream and downstream • Regular inspection of storage areas and annual inspection of basin containment liners • Inspection and cleaning of wastewater trenches • pollution control dams will be inspected and maintenance performed at least once a year	Factory manager Environment Manager	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
	closing phase • Contamination of surface water due to the demolition of contaminated infrastructure • Potential health impacts, impacts on surface water quality and aquatic biodiversity	• Remove potentially contaminated infrastructure and eliminate • Maintain drinking water and wastewater channels until all potentially contaminated infrastructure has been removed • Proper disposal of all unused chemicals and reagents (eg, collected by suppliers) • Once the potentially contaminated infrastructure is removed, backfilled, leveled and rehabilitated the treatment site	• Two years of monitoring and maintenance • Follow-up of the rehabilitation	Contractor Operations Director environmental officer	• • Safe disposal of any potential contaminated infrastructure
vehicle wash station	*Construction phase:* clearing of the site and consequent loss of vegetation	• Build a vehicle wash station • the base of the washing station must be cemented and bunded • A trench / drain must be installed at the open end of the washing bay to capture all contaminated water	• Monitor the levels of the water tank and pump for reuse • Clean the barrier trench regularly (more frequently during the rainy season)		• • No contamination outside the site
	Operation phase: oil spills and contaminated water on the soil surface	• No washing of vehicles on open floors • the pond water will be connected to the oil separator system, • Hydrocarbons will be stored with other hazardous waste streams as included in Table 11.4 • silt removed from the tank and deposited at TSF or at the bioremediation facility • Bioremediation of soils containing spill	• Regular visual inspections of soils around the wash station to check for potential oil spills • Annual inspections of the integrity of the dams and the car washing bay	Environmental officer	• No oil spill
	Closing phase: soil contamination by hydrocarbons	• Elimination of all hydrocarbons • Chemical detoxification • Removal of all contaminated soil up to 1m below the level of contamination • Bioremediation of contaminated soils • Elimination of washing stations according to environmental risks	• Follow-up of rehabilitation	Contractor Environmental officer	• No residual impact
Discharge of excess water from the pit into the	*Construction phase* • Excess water can be dumped to start mining		• Monitoring of the water quality of the pit • monitoring of aquatic	Environmental officer	Limited discharge

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
environment	• Water with high levels of contaminants threatens surface waters and impacts aquatic biodiversity and human health		biodiversity as required by the Site Monitoring Plan		
	Operation phase • Water with high levels of contaminants contaminates surface water resources and impacts aquatic biodiversity and human health • Cyanide-containing water can have negative impacts on the quality of surface water and have impacts on biodiversity (especially aquatic biodiversity) of humans and livestock	• Strive to manage the mine without landfill generation where all the water will be reused in the process • In the event of rain exceeding the probability 1: 100 years 24 when the water will have to be evacuated, to evaluate the quality of the water established before discharge - the treatment of this water could be necessary before its rejection. • If the quality of the water exceeds the limits of Table 6 1 or as established by CIAPOL, it must be treated before being rejected. • In the event of a spill, the monitoring of the quality of the water must be done until stabilization • The reasons for the spills to be investigated is the risk of re-offending assessed through significant corrective actions.	• surface water monitoring: according to the site monitoring plan • Monitoring water levels during storms and acting proactively in terms of pre-discharge treatment • monitoring aquatic biodiversity according to the site monitoring plan	Mine / General Manager Environmental Officer	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO
	closing phase • Deterioration of the water quality from the pit	• Maintain and improve the perimeter to an appropriate width and height • Maintain erosion control measures • Remove all equipment from the pit • Removing path from the mine to reduce access	Two years of monitoring the maintenance of water quality • Monitoring, rehabilitation and revegetation according to the site monitoring plan • Two-year annual monitoring of pit stability	Environmental Manager Geotechnical engineer	No deterioration in the quality of the water coming from the mine
Water catchment	The project will have positive water balance. No water production from surface water resources is planned. If the DFS indicates that extraction is necessary, an extraction permit must be submitted to the Ministry of Water The conditions of the application and the approval process must be respected.				
	Construction phase	All workshops will be covered	• Construction Monitoring	Project Manager	• Construction

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
		• Floors will consist of an impermeable waterproof concrete base • the water management infrastructure for the separation of drinking water and wastewater / systems will be put in place • Barrier trenches will be installed at the entrance of the workshop and the zone and after covered with paving stones • Supply zone will be cemented and refueling equipment equipped with automatic shutdown • the design must be approved by the project Manager		Contractor	plans will help prevent spills
	Operation phase • Contamination of soils, surface water, groundwater and potential impacts on vegetation	• All equipment, machinery and vehicles will be subject to a preventive maintenance program • the Barrier trench will be cleaned regularly • Methods for dry cleaning of workshop floors will be done as much as possible • Spill kits will be placed in all areas where possible leaks are to be considered (workshops, storage areas, etc.) • the supply zones will be dammed • Bio-remediation of contaminated soils	• The functionality of the oil separator will be checked regularly • Oils from the oil separator should be stored in accordance with the waste management measures included in Table 11.4. • Oil separators and barrier trenches will be cleaned regularly • Groundwater monitoring upstream and downstream according to the monitoring plan of the site	Workshop chief director of the mine QHSE agent Logistique Manager	No trace of hydrocarbons in surface and groundwater • No trace of soil contamination
	Closing phase	All possible contaminants will be eliminated • Infrastructure will be cleaned with environmentally friendly chemicals • Infrastructure will be removed and eliminated because of the danger it represents • Potential contaminated soils will be returned and bio-sanitized • All areas will be rehabilitated to enhance natural vegetation	• Visual inspection of soils in relation to contamination • Two years of follow-up	Operations Director Environmental Manager	the vegetation cover of 75% (at least) is reached • No residual contamination

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
Wastewater treatment plant	Refer to Table 11.4				
Groundwater management					
TSF and waste dump	Construction phase • Loss of biodiversity due to site cleanup • Increase in fugitive dust emissions • Loss of topsoil • Increased erosion	• demarcate cleaning footprints • stagger cleaning as required • implementation of dust removal measures • Ensure topsoil is removed and stored for use during rehabilitation • Design and build sites that can reduce runoff and erosion on cleared areas • Construct silt traps from stormwater to reduce erosion and contain silt loads	• • Monitoring Construction work	Project Manager environmental officer Director of Construction QHSE agent	footprints reduced to a minimum Dust emitted on vegetation is limited • No erosion
	Operation phase • Contamination of groundwater resources • Use of polluted groundwater for irrigation and livestock can lead to health problems • The formation of a plume of contamination in the deep aquifer following the infiltration of contaminants from the mine's infrastructure	• A complete program for the classification of additional waste prior to transport to TSF and waste rock is commissioned • trenches will be constructed where required along portions of the waste rock dump to intercept water that would flow on the waste dump area and reduce the risk of erosion of the topof the dump; and seepage into groundwater • Leak detection systems will be installed if necessary, follow-up drilling, pressure loss detectors, etc., for example	• Assessments of classification of additional waste before start of construction work • Groundwater monitoring: according to the site monitoring plan • Update the groundwater contamination model regularly	Director of Construction Project Manager	No deterioration in the quality of surface water above the limits set by CIAPOL or WHO
	Closing phase Refer to closure phase in the section on surface water impacts and management requirements		Update the groundwater contamination model after two-year post maintenance follow-up to avoid pollution plume, which could impact drinking and potable water resources	• Operations Director • Hydrogeologist	No spread of pollution
Pit dewatering	Construction phase • The formation of a folding cone associated	• the water is reused in the process • Monitoring the quality of the water will be necessary	• Monitor groundwater levels and the quality of community boreholes according to the site	Environmental Officer CCC	No impact on water security for the community

Aspect or activity	Possible Impact	Management Requirement	Tracking requirements	Roles and responsibilities	Key performance indicators
	with the lowering of the water table • Reduced water security and its availability for surrounding communities • Contamination of surface water in case of release	• Water treatment within the limits indicated in Table 6.1 or as indicated by CIAPOL in the matter if the water quality does not meet the required limits • Ensure that a complaints register is available and communicated to the community to help identify impacts on water safety • provide alternative water sources for communities to prevent drying up of community water resources	monitoring plan. • Regular feedback from communities during community meetings		No deterioration of water quality
Mining operation, including sumps	Operation phase • Contamination of shallow aquifers supplying communities • Contamination of aquifers and formation of contamination plume	• Update every two years of the groundwater contamination and dewatering model • Expansion of the ongoing surface and groundwater monitoring program so that all potential areas of impact are covered • Ensure that all areas that can lead to contamination are sufficiently doubled and that clean water is diverted away from wastewater areas • Regular maintenance of all wastewater containers and diversion infrastructure • Continued open communication with communities through established committees • Provide communities with a reliable source of water in the event that the mining operation impacts the quality of the water • Regular maintenance of wastewater containment and management of stormwater infrastructure	• Regularly update the groundwater contamination model • Develop the groundwater monitoring network to cover all potential sources of contamination • Conduct groundwater monitoring according to the site plan • Continue monitoring of groundwater at community water supply level • An annual follow-up of the integrities of the water storage pond	Environmental Officer CCC	No deterioration of groundwater quality

11.5 Air Quality Management

Table 11-6 Air Quality Management

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
TSF Cyanide	*Operational and Closure Phase* Release of dust during dry period leading to nuisance Dust falloutl on flora Potential health impacts if concentrations of cyanide high	• Alternate use of discharge points at the TSF to try and keep the tailings beach moist • Use dust suppression during dry season • Ensure concurrent rehabilitation and revegetation	• Air Quality Monitoring for SO_x, NO_x, PM_{10}, $PM_{2.5}$ and fugitive dust • Update monitoring locations as required. • Air quality limits not to exceed the limits set by CIAPOL and the WHO (whichever are the most stringent) included in section Table 11-	Environmental Officer Mine/ General Manager	WHO and CIAPOL air quality limits not exceeded
Open pits, roads and working areas	*Construction and Operational Phase* Dust fallout leading to nuisance, impacts on plants and potential health impacts	• Progressive clearance of vegetation as required by the different phases of construction and operation • Concurrent rehabilitation as construction and operational activities ceases • Implement dust suppression methods, e.g. water browser, Dustiside if required etc. • Vehicles carrying loose material to be covered with sheets • Vehicles and machinery to be serviced on a regular basis • Implementation of speed limits and other speed control measures • Dust suppression on dust-generating points in the process plant • Formal reporting of excessive dust	• Initial induction and annual medicals • Occupational health monitoring of employees on an annual basis • Continued air quality monitoring as per the site Monitoring Plan • Monitoring of dust fallout • Inspection and keeping of maintenance records	SHEQ Medical staff Environmental Officer Workshop manager	Air emissions and dust fallout remains within the CIAPOL and IFC limits
	Closure Phase:	• Risk assessment in terms of air quality during closure • Implement effective dust suppression measures,	• Employee medicals • Occupational health monitoring of employees on an annual basis	• Main contractor • Mine/ General Manager	• Air quality within the limits

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		such as watering, Dustiside etc. • Undertake concurrent rehabilitation during operational and closure phase • Regular maintenance of machinery and vehicles • Adherence to speed limits	• Continued air quality monitoring as indicated in the table above • Monitoring of dust fallout • Inspection and keeping of maintenance records	• SHEQ and Environmental Officers	included in Table 6-10 • Vegetation coverage of at least 75% to be achieved

Air quality monitoring should be conducted as per the site Monitoring Plan and Table 11.6 below:

Table 11-7 Air Emission Limits

Substances	CIAPOL Limits		WHO Limits (µg m^{-3})
	Applicable at hourly release rate of	Maximum allowable concentration (mg/m^3)	
Total dust	< 1kg/h >1kg/h	100 50	n.a
Carbon monoxide	>1 kg/h	50	Max 8 hour mean - 10,000
Sulphur oxide (expressed as sulphur dioxide)	>25 kg/h	500	Annual mean – 50 10 minute mean - 500
Nitrogen oxide (expressed as nitrogen dioxide)	>1 kg/h	50	Annual mean - 40 1 hour mean - 200
Discharges of various gaseous substances such as HCN	>50mg/h	5 mg/m³	
PM_{10}	n.a.	n.a	Annual mean - 20 24 hour mean - 50
$PM_{2.5}$	n.a	n.a	Annual mean - 10 24 hour mean - 25

11.6 Blasting, Reagents and Chemicals

Reagents, chemicals and explosives have the potential to cause contamination to the environment and a threat to human health and safety if not handled and stored correctly.

This section deals specifically with:

- The types of chemicals and reagents that will be used and stored on site;
- Potential impacts and management measures not addressed in the previous sections during the various phases of the Project; and
- Storage and handling requirements as addressed in the previous sections.

The management and monitoring requirements for the chemicals, reagents and explosives are included in **Error! Reference source not found.**7.

Table 11-8 Reagent and Chemical Usage, Handling, Storage and Management

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
	Management and Mitigating Measures applicable to Chemicals and Reagents during Construction Phase				
All reagents and chemicals	*Construction Phase* Storage on open soil can cause contamination to soil and surface water	• During the period that permanent storage areas are constructed, chemicals and reagents will be stored in secondary containment within containers Permanent storage areas for **reagents and chemicals** will be constructed that will comply with the following requirements: • Separate reagent and chemical storage areas will be constructed for bulk reagents • The warehouse and its surrounds will be constructed with sufficient provision for truck and forklift access • The base of any chemical and reagent storage areas will consist of a concrete impervious floor, a bund on the outer site and a sump inside to capture spillages should it occur • All bulk chemicals will be stored in bunded areas in	• Monitor that no chemicals or reagents are stored on open surfaces • Monitor that construction is according to best practices	Construction Manager SHEQ Officer Environmental Officer	No contamination during construction phase as a result of reagent and chemicals Provision of storage facilities that will reduce the risk of chemicals and reagents to be stored

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		accordance with HAZMAT requirements • MSDS for all chemicals being stored to be available at the storage location as well as at the site Clinic • **Cyanide** and **acids** will be both stored separately. • For the storage of **Cyanide** a secure facility will be constructed and access controlled • The building will be constructed in such a manner that ingress of water is avoided at all times • The necessary impervious flooring, sump and ventilation where required will be constructed • Dust from lime will be controlled For **diesel** storage a tank farm consisting of storage tanks will be constructed • Secondary containments consisting of impervious concrete base will be constructed • The capacity of the containment bund will be 110% of tank volume • Lockable emergency valves will be installed to drain potential spillages			
Hydrochloric acid	*Operational Phase* • Not classified as a hazardous substance • Can cause irritant effect when in contact with skin	• Rinse skin immediately if contact is made • Rinse eyes with water in case of contact with eyes and see an ophthalmologist • Use dry clean methods to clean up spillages • Ensure that spill kits are put in place • MSDS to be available at storage area • Incident management training to all applicable employees • Store in a specially prepared, dry storage area that is well ventilated and access is controlled • Ensure that the correct PPE is used • Store in corrosive resistant containers with a resistant liner • Containers to be disposed of appropriately (e.g.	• Monitor the integrity of the containment area on an annual basis, including the sump • Monitor for spillages and incidents • Monitor cleaning schedule	Store Manager	Effective containment which holds no health or environmental risk

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		Removed by suppliers) • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)			
Sodium Cyanide	*Operational Phase* • Very toxic by inhalation, skin contact of swallowed • In contact with acids, hydrocyanic acid which is combustible and may lead explosive gas mixtures may be release • Toxic to aquatic organisms	• Put the necessary chemical fire extinguishers in place • Fire residue needs to be disposed as hazardous waste • Avoid contact with other acids • Store in dry place • Contact with any water should be avoided • MSDS to be available at storage area and site Clinic • Incident management training to all applicable employees • Relevant emergency response equipment on site to respond to any cyanide emergency event • Emergency response training to Emergency Response Team (ERT) • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS) • Routine inspection and preventative maintenance program in place for all cyanide-related infrastructure • Recommended PPE to be worn by all personnel working with cyanide • Cyanide antidote available at the site Clinic	• The storage area will be monitored on a daily basis • Cyanide emission alarm systems will be put in place around the site and tested on a regular basis • Monitor that no incompatible material is stored in association with the Sodium Cyanide • Individual cyanide detectors available for ERT personnel and first responders	Plant Manager Environmental Officer	No incidents
Diesel **Oil**	Contamination of soil and groundwater • Toxic to aquatic organisms, with potential long-term adverse effect • The product may form flammable mixtures with air when heated	• Fire extinguishers will be put in place in accordance with legal and best practice requirements • Maintain sump and bunds • Ensure that spillages inside and outside of the tank areas are cleaned up immediately • Spill kits will be put in place • Immediate bioremediation of contaminated soils • Training of personnel responsible for refueling • Cemented refueling area will be cleaned on a regular basis	• Monitor the integrity of the containment area on an annual basis, including the sump and bunds • Monitor for spillages and incidents • Monitor cleaning schedule • Monitor the servicing of fire extinguishers	• Environmental Officer	• No spillages inside or outside of diesel and oil storage areas • No other materials stored in containment areas

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
	above the flash point. • Category 3 carcinogen Harmful: may cause lung damage if swallowed	• Incident procedure will be put in place			
Flocculent MAGNAFLOC 33	*Operational Phase* • This is not classified as a hazardous substance • May cause some eye irritation May cause some irritation to the respiratory system if dust is inhaled • May cause skin irritation • It does not burn readily but as with many organic powders, flammable dust clouds may be formed in air	• Use PPE as recommended in the MSDS • Take precautionary measures against static discharges • Stored in the reagent and chemical storage area. • The base of the warehouse will consist of a concrete impervious floor, a bund on the outer site and a sump inside to capture spillages should it occur • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)	• Monitor the integrity of the containment area on an annual basis, including the sump • Monitor for spillages and incidents • Monitor cleaning schedule	• Store manager	• Effective containment which holds no health or environmental risk
Lime Calcined	*Operational Phase* • Release can lead to irritation to the skin and eyes • Release can lead to irritation to the	• Store in a dry place • Enclosed roofed, bunded stores with an impervious surface and ventilation. • Do not store near incompatible materials • Use dry cleaning methods to clean up spillages • Care should be taken not to create dust when used to	• Storage integrity will be monitored at least annually	• Store manager • All personnel responsible for handling the material	• No health and safety risk to employees • No spillages

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
	respiratory system • Increase in pH if released into surface water resources	avoid inhalation • Use the necessary PPE when handling the material • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)			
Sodium Hydroxide	• Severe skin burn when in contact with the skin • Corrosion of containers can lead to spillages	• Store in specially prepared storage area that is cool and well ventilated • Sore in closed original containers • Keep away from incompatible materials • Ensure that any spills will be captured • Wear the necessary PPE when handling the chemicals • Ensure that the necessary fire extinguishers are in place • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)	• Monitor containers regularly • Monitor storage area integrity at least annually	• Store manager • Personnel responsible for handling the chemicals	• Secure containment of the chemical • No incidents
Activated Carbon	• Non-hazardous material • Dust can cause irritation to eyes or inhalation discomfort	• Ensure that fire prevention methods and extinguishers are regularly serviced • Contain any run-off • Sweep and clean up ay spillages • Keep in closed containers in a dry, storage area • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)	• Monitor for spillages as used • Monitor the integrity of the storage area on a bi-annual basis	• Store manager • Personnel responsible for handling the chemicals	• No spillages • Integrity of the storage area is maintained
Fluxes (Borax)	• Contact with eyes or skin can lead to irritation • Release can lead to irritation to the respiratory system • Non-hazardous with no special transportation requirements	• Store in original containers in a cool area • Ensure that containers remain sealed • Wear the necessary PPE when handling the material • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)	• Monitor the integrity of the containment area on an annual basis, including the sump • Monitor for spillages and incidents • Monitor cleaning schedule	• Store manager • Personnel responsible for handling the chemicals	• No spillages • No incidents • Integrity of storage area is maintained
Blasting Detonators,	• Explosions can	• Design and construct the explosives magazine to	• Access will be monitored	• Mine Manager	• High security

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
Primers etc plus Emulsion or ANFO (both nitrogen-based products)	lead to severe injuries and fatalities	comply with relevant international standards • Detonators etc will be stored in bunded, fully enclosed facilities (eg. sea containers) that are separated from the other storage facilities by earthen bunds • Storage facilities will be earthed • Material to remain stored in original containers unless mixing on site required • Mixing to be done in specific, dedicated mixing tanks • Emulsion to be stored in tanks/silos • Emulsion spillages will be cleaned up immediately • The magazine will have a 500m radius for safety reasons • The magazine will be provided with a high security fence • Access to the magazine will be limited and controlled • Security person/s will be posted at the magazine at all times • Explosives will be transported by a licensed company according to international best practice • Lightening conductors will be maintained • Comply with the legal requirements for transportation and handling included in the Safety Data Sheets (SDS) • Authorised Shot Firer to be responsible for all blasts • Blast preparation activities to be suspended in the event of lightning activity • Access to the shot during loading of the holes to be restricted to blast team personnel only; others must be escorted if they must go on the loaded shot • Sensitisation of the surrounding communities with regard to blasting prior to the first blast occurring • Blast noticeboards on site and in the relevant communities must give sufficient advance warning of blasts (preferably 24 hour' 'notice)	through a security gate system • The integrity of the magazine facilities and infrastructure will be monitored on a regular basis • Integrity of the security systems will be reviewed regularly • Blast monitoring for airblast (noise) and vibration to be done for each blast • Final check of blast exclusion zone to be conducted immediately prior to blast • After the blast, shot firer must check the shot to ensure all holes were successfully detonated before giving the all clear for people and equipment to return • Pit walls to be checked for stability issues post-blasting	• Magazine Manager	measures will be maintained • Integrity of the magazine will be maintained

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		• Restricted 500m exclusion zone must be cleared 15 minutes prior to blasting; all people must be clear and track equipment must be parked at a safe distance (might be <500m) • Blast guards to be stationed at key locations on the 500m blast exclusion zone to restrict access			
Transformer Oils	• Irritation to skin and eyes when released	• Store away from any source of ignition • Dry ventilated storage area is required • Ensure that dry chemical, carbon dioxide and water extinguishers are in place and serviced on a regular basis • Contain all spills to avoid contamination of the environment • Use the necessary PPE when handled especially respiratory protection • Used oils to be recycled • Comply with the required transportation requirements included in the MSDS and Safety Data Sheets (SDS)	• Monitor storage practices on a regular basis • Monitor the integrity of the storage area at least annually • Monitor containers for any spillages	• Store Manager • Personnel responsible for the handling of chemicals	• No spillages • No incidents
Hydrochloric acid	• When exposed can lead to skin burns, damage to the eyes, respiratory irritation and damage to organs if exposure is prolonged	• Store in an acid-resistant, dry storage area that is well ventilated and has controlled access • Ensure that the correct PPE is used • Store in corrosive resistant polypropylene containers with a resistant liner • Use dry cleaning absorption should spillages occur • Containers to be disposed of appropriately (e.g. removed by the suppliers) • Comply with the required transportation requirements included in the MSDS and SDS	• Monitor storage practices on a regular basis • Monitor the integrity of the storage area at least annually	• Store manager • Personnel responsible for handling the chemicals	• No incidents • No spillages
	Management and Mitigating Measures applicable to Reagents and Chemicals During Closure Phase				
All reagents and chemicals during closure phase	Chemical or reagent contamination	• At closure, reagent and chemical tanks are flushed and cleaned. • Explosives and chemicals will be disposed of	• Pre-decommissioning risk assessment • Contaminant inspection	• Operations Manager • Contractors	• All chemicals and reagents removed and

Aspect or Activity	Potential Impact	Management Requirement	Monitoring Requirements	Roles and Responsibilities	Key Performance Indicators
		appropriately (e.g. Returned to the supplier or will be disposed of by a licensed contractor). • The suppliers and contractors will have the necessary transport approvals in place • All storage infrastructure will be removed and disposed of appropriately (eg.on the TSF)	• Rehabilitation monitoring	• Environmental Officer	safely disposed • No residual impacts

The MSDS's for the various reagents and chemicals are included in Appendix.

11.7 Community Aspects

11.7.1 Community Management Requirements

The detail on the community impacts and required management measures highlighted during the ANDE Inquiry are included in Table 11-6, whilst the minutes of the Public Inquiry are included in Appendix. Social management and monitoring will be undertaken throughout the Project, and monitoring is detailed in section 11.7.3. The current community liaison structures which are already in place will be expanded for the purpose of the Project. Roles and responsibilities are outlined in section 0.

The rest of the management measures are included in Section 8.11 of the ESIA.

The Social Management Plan comprises a set of initiatives or management programmes that outline how Yaouré intends to move forward with the mitigation measures identified in the impact evaluation section, as follows:

1. Stakeholder engagement;
2. Livelihood restoration;
3. Artisanal mining;
4. Local economic participation (including Recruitment Plan, Procurement Plan)
5. Worker housing;
6. Influx management; and
7. Community development.

The Cultural Heritage Management Plan and Community Health, Safety and Security Management Plans are appended separately to the ESIA Report.

Table 11-6 Management Requirements for Social and Community Aspects

Aspect	Potential Impact & Objectives	Management Requirement
Stakeholder Engagement and Community Committee	Ensure that Project affected communities and other stakeholders are well informed about the Project, its potential environmental and social impacts, and proposed mitigation measures; Consult widely with stakeholders on the above and both solicit and incorporate their informed input regarding Project design, environmental and social performance, and other community initiatives; Facilitate the active participation of stakeholders in the planning and implementation of the Social Management Plans presented herein; and Position residents to benefit as much as possible from the opportunities afforded by the Project and to be impacted as little as possible by its challenges.	*Economic & Employment Impacts* • Engage with national and regional authorities to encourage cooperation in the governance system to maximize benefits for the impacted communities from induced economic growth and payment of royalties and taxes; • Create working groups within stakeholder management governance structure where feasible (i.e. Local Economic Participation Working Group) to allow for a participatory approach to planning and decision-making; • Work with local stakeholders to undertake initiatives such as: – Define "Local" and "Regional" for purposes of employment and procurement planning – Undertake a skills survey – Establish a Local Employment Committee and advertise positions locally (radio, local employment offices, etc.); – Provide skills upgrading programmes and/or apprenticeships for local area youth or Project staff; – Support local education initiatives; – Establish a Local Job-Seekers Database; – Facilitate access to information for procurement to help local businesses stay competitive; – Facilitate partnerships between regional finance and training providers with local businesses; – Undertake local business surveys; – Establishment a Vetted Local Supplier Database; and – Monitor and evaluate Project performances on employment and procurement. *Economic Displacement* • Create working groups within stakeholder management governance structure where feasible (i.e. Land Acquisition & Livelihood Restoration Working Group, Community Development Working Group) to allow for a participatory approach to planning and decision-making; • Work with local stakeholders to undertake initiatives such as: – Undertake definitive surveys; – Define entitlement matrix and type of entitlements; – Identify options for replacement (in cash or in-kind) of any built or planted assets lost due to land acquisition by the Project, including locational advantages and access; – Define livelihood restoration and improvement measures; – Identify viable alternative livelihood activities for non-restorable / improvable livelihoods; – Identify vulnerable people and categories affected by economic displacement; and – Monitor and evaluate Project performances on economic displacement impacts. *Population and Community Change* • Create permanent consultation forums with regional and local stakeholders where feasible(i.e. Regional Consultation Forum, Local Consultation Forum) to allow for a participatory approach to planning and decision-making; • Cooperate with the UN bodies (i.e. ONUCI) on national reconciliation programmes and appeasement of local communities; • Work with local stakeholders to undertake initiatives such as: – Support the development of community infrastructure and services; – Control and reduce pressure on local goods and services where these are already scarcely available; – Monitor on-going in-migration and provide regular feedback to local communities; – Ensure that induced inflation and pressure on local services and infrastructure does not unduly impact vulnerable households; – Supporting the extension of policing services at sub-prefectural level to prevent the intensification of violent conflicts; and – Monitor and evaluate Project performances on population and community change impacts.
Livelihood Restoration	Acquisition of land likely to result in economic displacement of people, households and communities that rely on the assets within the footprint as a means of livelihoods, namely agricultural lands and communal resource lands.	Yaouré has a Framework Livelihood Restoration Programme (FLRP), which defines how the Project will acquire the land it requires and manage the resulting economic displacement impacts in keeping with IFC Performance Standard 5 and relevant Ivorian legislation and regulation. Specifically, the FLRP comprises the following: • High level framing of the entire land acquisition and livelihood restoration process from beginning to end; • A "Plan for a Plan" outlining the likely scope of displacement, an overall approach, future stakeholder engagement, proposed eligibility & entitlement policies, high-level supportive programmes, and a work programme and schedule for remaining steps in the process; • Livelihood restoration to be done in accordance with the rate prescribed by the Ministry of Agriculture included in Decree No 2014-397 dated 25 June 2014 determining the Procedure for the Application of the Act No 2014-138 of 24 March on Mining Code and in accordance with the IFC PS 5. • As part of the FLRP the following activities may be carried out: - Agreement on a cut-off date through a Consultation Forum jointly constituted with those affected; - Confirmation of livelihood loss; - Collaboration with Government to agree on the process that is based on good faith negotiations; - Assessment of alternatives to avoid the loss of livelihood; - Community engagement programme that will ensure the informed consultation and participation of those affected; - Preparation of a livelihood restoration programme based on IFC PS5; - Assistance Programme for Vulnerable People in which special assistance measures will be developed where vulnerable people's livelihoods are affected; - Implementation of a grievance procedure; - Compensation for affected immoveable assets at full replacement value; - In-kind compensation where cash compensation carries a significant risk for loss of livelihood or standard of living; - Investigate and implement appropriate means to integrate woman's perspectives and needs into the livelihood restoration planning; - Occupation of mine land will only commence once compensation has been finalized; and - A monitoring programme will be implemented throughout the livelihood restoration programme to ensure that living standards and means to earn a livelihood is restored It must be noted that rotational farming is taking place in the area of potential impact. The current agricultural land is included in the land use map included on Figure 6-1.
Artisanal Mining	Project-related land acquisition will result in the loss of a small number of active artisanal mining sites located in the Project footprint. Management of the resulting economic displacement impacts will be addressed through the Livelihood Restoration (FLRP) process.	*Impacts & Mitigation* The Artisanal Mining Management Plan (AMMP) refers to the economic displacement impacts identified in the social impact assessment section. The following mitigation measures are to be reflected in the social management plans (i.e. the AMMP or the FLRP): • Define a livelihood restoration programme to support the development of alternative livelihood activities;

Aspect	Potential Impact & Objectives	Management Requirement
	Yaouré proposes to collaborate with Government authorities, community stakeholders, and representatives of the artisanal mining community in the design and implementation of an Artisanal Mining Programme that focuses on ongoing legal artisanal mining activities. Objectives of this programme will be as follows: • Ensuring the safety, security, and economic viability of Project construction and operations; • Not limiting Yaouré's ability to explore and potentially develop other commercially viable deposits elsewhere in its Exploration Concession; • Demonstrating the viability of alternative livelihoods through the Livelihood Restoration Programme (e.g., irrigated market gardens); and, Working with Government Authorities to formalize and legalise ongoing artisanal mining activities, as prescribed under the new Mining Code.	• Providing support to Government initiatives to encourage legal artisanal mining activities within the legal framework of the 2014 Mining Code; and • Include local artisanal miners in any future socio-economic surveys; *Consultation* • Participate in any Artisanal Mining Working Group with representatives of local Government, nearby communities and customary landholders, and the artisanal mining community. The Working Group should be a group within the planned Regional and Community Consultation Committees. • Discuss any concerns and challenges. • Regular communication with a wide-range of stakeholders within and outside the Exploration Concession. *Artisanal Mining Policy & Monitoring* • Registration of active artisanal mining sites and participants to serve as a baseline for planning, implementation and monitoring purposes. • Establishment, monitoring, and enforcement of a "Zero Tolerance" policy for artisanal mining activities or for activities that do not conform to the agreed "zoning plan". *Assistance with the Legalisation and Formalisation of Artisanal Mining* Assist the government with the design and implementation of a campaign with appropriate guidance, training and materials to: • Improve health, safety and environmental performance. • Eliminate use of child or indentured workers. • Assist with regulatory requirements regarding formalization and reporting. • Improve productivity and financial returns. • Support formalization of local exchange markets for gold from artisanal mining. *Alternative Livelihood Activities* Regularly demonstrate the viability of alternative livelihoods focused on agriculture or vocational training through any Livelihood Restoration Programme and the Community Development Programme to attract people, and particularly youth, away from artisanal mining.
Development Plans, Local Villages and Peripheral Villages' Economic Participation	Yaouré recognises that local participation in the economic opportunities generated by the Project can have significant benefits, including: • Stronger relations with nearby communities; • Higher contribution to local economic development; • Reduced risks of operational delays, stoppages or protests; • Improved supply chain and operating efficiencies; and • Greater diversification and resilience of the local economy.	• Yaouré proposes to maximise the capture of Project-related employment and procurement opportunities by those living in communities within the Area of Local Direct Influence (ALDI) and, to a lesser extent, the Area of Local Indirect Influence (ALII) and the Area of Regional Influence (ARI). • Yaouré proposes to collaborate with relevant stakeholders to prepare and implement both a Local Recruitment Programme and a Local Procurement Programme. These initiatives will be closely coordinated with other initiatives within the overall Social Management Plan, and are detailed below. • The Community Forum (e.g. CCC) which will be established will furthermore decide on the most pressing issues which need to be addressed from the compulsory Community Development Fund that has to be provided.
Recruitment	During construction and operation combined, the Project will provide employment for many people. During construction it is assumend 900 temporary employment and in operation, it is currently assumed that up to 400 people will find permanent employment at the Project. However, contractors and temporary jobs may add to this number and increase the overall employment opportunities that come with the Project. During closure and post-closure, this number will drop significantly. Yaouré proposes to collaborate with relevant stakeholders in the design and implementation of a Recruitment Programme (RP) to maximise local capture of direct and indirect employment opportunities generated by the Project. Objectives include the following: • Reinforce a transparent and effective local recruitment system that is based on a preference for the "most local" qualified, skilled and experienced candidate and fair distribution of opportunities; • Ensure a constant and reliable source of local unskilled labour for the Project during construction and operations; • Discourage influx migration into the region caused by expectations of employment with the Project; • Avoid unduly straining the availability of labour for traditional livelihood activities (e.g., farming); and, Ensure that woman and other traditionally excluded groups are provided with equal access to employment opportunities.	*Impacts and Enhancement* The Recruitment Plan refers to the economic and employment impacts identified in the social impact assessment section. The following enhancement measures may be reflected in this social management plan: • Local hiring for unskilled positions (HRD-POL-011) • Local preference accorded to local candidate with appropriate qualifications, skills and experience for project need • Positions advertised locally (radio, local employment offices, etc.) • Effective communication and engagement strategies on employment opportunities (type, duration, qualification etc.) • Skills upgrading programmes for Project staff • Facilitate access for local employment for skilled positions • Apprenticeships for local area youth • Support for local education initiatives • Local professional skills survey and establishment of a Local Job-Seekers Database • Work with local governance structures (e.g. Working Group on Local Economic Participation) *Communications* Establish a Local Employment Committee with representatives of local Government and nearby communities. The Committee could be a group within the planned Regional and Local Consultation Committees. • Update on any changes to Project recruitment processes. • Share current and projected recruitment requirements. • Report on Project recruitment statistics. • Discuss any concerns and challenges. Prepare and distribute a public document that summarizes final policies and procedures regarding recruitment of local workers. Explore the possibility to create a Local Community Information Centre that is located within a local community. The Centre would act as a hub to disseminate information, hold workshops and community consultations, and serve as a venue for on-going training and technical assistance activities. Regular communications with local communities including the provision of regular updates on Project employment needs, recruitment policies, job descriptions, local employment statistics, etc. *Local Recruitment Policies* Review of Project staffing plans to identify current and potential opportunities for unskilled workers from the local area and establish clear minimum skills and experience requirements for each job type. Put in place clear application guidelines, selection criteria, and provide feedback to unsuccessful candidates. Define "local" for the purposes of distributing employment opportunities and a fair and transparent system for distributing opportunities within that geographical area. *Local Recruitment Database* Establish a database of candidate workers who are bona fide "locals" – i.e. verified through national ID – and who have been pre-screened and provided with basic employment readiness training. Create a policy mandating use of the database for recruitment of all unskilled workers, by Yaouré and its contractors. Provide pre-employment screening and training: • Verification of residency and experience / skills; • Basic Health and Safety Education induction and assessment. • Introduction to the Project and working with large company; and

Aspect	Potential Impact & Objectives	Management Requirement
		• Confirmation of ability to work. *Skills Upgrading and Mentoring* Identify skilled positions that can be filled through skills upgrading of and facilitate training of local employees. During the construction phase, local unskilled employees can be trained to assume semi-skilled and skilled positions during operations. Activities to facilitate skills upgrading could include: • Flexible work schedules; • Support to access education finance; • Preferential recruitment for skilled positions to be given to internal local candidates; and • Provide financial literacy training for all employees. *Local Skills Development* Extend availability of vocational training programmes as part of Livelihood Restoration and Community Development Programme to local residents on a cost-share basis. Examine potential use of apprenticeships to encourage skills development locally.

Procurement	Similar to the Recruitment Plan, Yaouré proposes to work with local and regional communities, businesses, and government to design and implement a Procurement Plan that maximises the Project's local and regional content. Objectives include the following:
	• Develop partnerships with local and regional businesses, as well as chambers of commerce, to maximise local procurement;
	• Create a transparent and reliable procurement system that is based on the principle of "most local preference" while maintaining quality, safety, and cost;
	• Strengthen the resilience of the Project supply chain;
	• Support the sustainable growth of local / regional businesses and local / regional economic development; and
	• Discourage influx migration caused by business speculation through the development of local/regional businesses that are able to better meet Project procurement requirements.
		Impacts and Enhancement
		The Procurement Plan refers to the economic and employment impacts identified in the social impact assessment section. The following enhancement measures are to be reflected in this social management plan:
		• Facilitate access to information on procurement to help local and regional businesses remain competitive
		• Facilitate partnerships between regional finance and training providers and local / regional businesses
		• Local enterprise development activities to support the establishment of sustainable local / regional businesses
		• Local business surveys and establishment of a Vetted Local Supplier Database.
		
		Communications
		Establish a technical Procurement Working Group consisting of local and regional businesses, local Government officials, and representatives of local communities. The Working Group should be a group within the planned Regional and Local Consultation Committees.
		Prepare a public document that details Project local procurement policy and commitments.
		Organize regular local entrepreneur workshops to local communities to:
		• Provide updates on changes to Project procurement processes – provide trainings and guidelines
		• Share current and projected procurement requirements
		• Support businesses to apply for open procurement
		• Report on procurement statistics for the past period
		• Register any businesses in database
		• Discuss any concerns and challenges; and
		• If requested, more detailed information around why a business was not selected for a tender to be provided (private or public as appropriate).
		Explore the possibility to create a Local Community Information Centre that is located within a local community. The Centre would act as a hub to disseminate information, hold workshops and community consultations, and serve as a venue for on-going training and technical assistance activities.
		
		Project Procurement Requirements and Policy
		Where possible, classify and categorize Project procurement requirements:
		• Compile a master list of existing and project procurement requirements – construction and operation.
		• Determine minimum and preferred technical requirements for each item – standards and specifications.
		• Categorize each item with regards to the following categories:
		  – Critical / Complex – international and national procurement of pre-vetted suppliers.
		  – Not Critical / Not Complex – national and regional procurement through established suppliers.
		  – Not Critical / Not Complex – regional 'set aside' with local preference for trade goods and services.
		  – Not Critical / Not Complex – local 'set aside' for value added goods that can be produced locally.
		Establish policy to prioritize local procurement first from ALDI, then from ALII, and finally from the ARI, all within the scope of the agreement signed with the Project;
		Develop a tiered procurement process that allows local and regional businesses to apply while maintaining integrity and outcomes of Project procurement requirements (i.e. competitive process).
		
		Local Supplier Database
		Support the Procurement Consultation Forum (or relevant technical group) to conduct a local business survey to establish a baseline of local businesses, their capabilities, and challenges / opportunities. As a technical procurement survey, this process should involve Project procurement, contracts, and community relation staff.
		Establish a Vetted Supplier Database
		• Application based. Local businesses must apply to be included.
		• Each business must indicate what goods and services it can provide and verify it meets the necessary requirements.
		• At a minimum, businesses must be registered with the relevant local government authorities.
		• Local suppliers must be registered within the local area (ALDI, ALII, and ARI).
		• Local suppliers are categorised based on their capacity and experience.
		Develop a tiered procurement process that allows local and regional businesses to apply while maintaining integrity and outcomes of Project procurement requirements (i.e. competitive process).
		
		Facilitate Access to Technical and Financial Business Development Services
		Consider facilitating technical support for businesses to improve their administrative and financial capacity in order to be vetted and included on the Supplier Database or to improve their ability to compete for larger and more complicated contracts.
		• Identify local and regional vocational training providers.
		• Put in place a programme for local businesses to participate in business development training.
		• Facilitate technical businesses to receive necessary accreditation and qualifications for technical goods and services.
		Facilitate the development of partnerships between financial providers and local businesses – particularly around the area of securing capital to allow local businesses to qualify for larger procurement contracts.

<table>
<tr><th>Aspect</th><th>Potential Impact & Objectives</th><th>Management Requirement</th></tr>
<tr><td>Influx</td><td>Yaouré recognizes that the Project will result in both direct and indirect influx impacts. The Project will add to existing in-migration trends from artisanal mining. Project factors that contribute towards influx include Project employees from outside of local communities as well as job seekers and entrepreneurs that provide services to the mine and mine employees. If not properly managed, rapid in-migration, or influx, often results in unsustainable pressure on local infrastructure and services, which in turn can impact community and individual health, social cohesion, and economic growth.

The Project's approach to managing these direct and indirect influx impacts will be closely aligned with the Project's other Social Management Plans (SMPs), in particular the Local Economic Participation Plan, Worker Accommodation Plan, and the Community Development Plan. These plans all contain policies and activities that are designed to minimize influx and address the impacts of any influx that may occur. The main objectives of the Influx Management Plan are to:
• Minimise Project induced direct and indirect in-migration;
• Reduce the potential risks and enhance the benefits of any population growth;
• Support national, regional, and local governments along with communities to better plan and manage population growth in nearby communities; and
• Increase the active participation of all stakeholder groups – including women, businesses, and youth – in the planning and management of population growth.</td><td>As noted in other SMPs, the Project will minimize influx by:
• Putting in place and enforcing clear local recruitment guidelines to disincentivise job-seekers from relocating into the area;
• Maximising the recruitment and training of locally resident employees;
• Managing the Project's approach to worker accommodation in such a way as to minimise the impact of rapid employment during construction through on-site camp accommodations to minimise contact between temporary employees and local communities; and
• Maximising the sustainable growth of locally based accommodations over the operations phase.
Additional components of the Influx Management Plan are the following:
Impacts and Mitigation
The Influx Management Plan refers to the population and community change impacts identified in the social impact assessment section. The following mitigation measures are to be reflected in this social management plan:
• Procure goods and services locally whenever feasible;
• Ensure that per capita baseline water availability is maintained throughout the lifecycle of the Project;
• Support the development of community infrastructure and services;
• Monitor on-going in-migration and consult regularly with local communities;
• Monitor local economy (livelihoods) and health and consult regularly with local communities;
• Work with permanent consultations forums of local and regional stakeholders to ensure a participative approach to planning and decision making;
• Manage all employment opportunities via off-site facilities. Do not offer any employment directly at Project sites or work areas; and
• Support the sustainable development of the local economy through the Local Economic Participation Plan.

Communications
Regularly update the Local and Regional Consultation Committees on influx issues and the delivery of related commitments and activities. Specifically to
• Provide updates on local population growth, health and social changes, and the status of local service and infrastructure.
• Discuss any concerns and challenges.

Local Development Plans
Support those local communities to be most impacted by influx in their efforts to put in place Local Land Use and Development Plans.
• Participate with relevant National and Regional Government and Line Ministries.
• Help to identify local service and infrastructure development plans – in particular health, water and sanitation, and police / security.
• Work with local communities to help monitor population growth and demand on local services and infrastructure.
• The Project to contribute to implementation costs with local communities to address indirect influx impacts through the Community Development Fund.
In accordance with the Project environmental commitments to ensure the re-vegetation and agricultural intensification activities are designed in such a way as to maximise the ability of local communities to sustainably maintain access to natural resources.</td></tr>
<tr><td>Employees Accommodation</td><td>• The Project planned to assume an large number of employement during the construction and operation phases ;
• Yaouré acknowledge that the accommodation of empoyees shouldhave negative impact negatively, if not well managed, on local communities and empoyees of the project. The final estimated employees numbers will be defined during the DFS. If well mamanged, the employment approachcould be a significant economic factor for the local communities, reduce operating expenditure of the project and provide good quality of life to employees.
• Consequently, the objectives are to assess the needs of employees' accommodations, so that as far as possible, reduce the number of people seeking for accommodation focusing on :
• Minimize in-migration and impacts on local communities resulting from employees ;
• Create good life conditions for employees and maintain a balance between work / daily activities allowing them to live preferably within the host communities with their families ;
• Reduce the travel time between the project and their residential by establishing transportation options ;
• Reduce the cost of life for the employees by providing good working conditions
• Increase indirect economic advantages of the project by promoting local purchasing by the employees of goods and services ; and
• Reduce the project operation costs by decreasing the number of persons elgible for accommodation at senior camp</td><td>• Impacts and mitigation measures
• For workers' housing, consider the economic impact on the population and the community and identify the jobs in the social impact assessment section. The following mitigation measures should be considered in this social management planning:
• Reduce the number of people requiring housing at the local level;
• Ensure that senior / qualified housing requirements do not increase the pressure on local goods and services that are barely available;
• Procure local markets, however, that the required goods and services are available according to the local procurement plan;
• Support the development of community infrastructure and services;
• Establish codes of conduct for employees living in the senior camp provided by Yaouré
• Work with the CCC to ensure a participatory approach to decision-making

• Communications
• Regularly update regional and local consultation committees on the project's approach to worker housing and discuss concerns and challenges.

• Analysis of workers' housing
• Conduct a detailed analysis and evaluation of housing options for project workers, including costs, benefits and local impacts.
• Identify housing needs of project workers during construction and operation;
• Evaluate locally available housing, services and infrastructure for health and safety, minimum standards, and standard of living;
• Identify local capacities to sustainably host the project's direct and indirect workforce;
• Identify and monitor speculative housing activities within local communities; and
• Identify existing transportation options for local and non-local employees.
• Analysis of the overall site for temporary camp housing for labor during construction.
• Temporary design that will allow camp housing to accommodate the largest temporary construction workforce while being reusable for other functions during operations; and
• Identify accommodation location that will minimize interaction with local communities.

• Local Development of Habitat
• If applicable, provide transportation for local and regional employees to allow them to reside at home and commute to the project site.
In order to support the sustainable development of the local housing stock during the operation phase:
• Provide advance notice to local communities and financial providers about potential housing needs.
• Encourage local land use and local development plans and have provisions to accommodate the housing of additional workers.
• Provide incentives for employees to live locally (ie transportation, family allowances, etc.)
Support Local employees and housing construction for non-local employees.</td></tr>
</table>

Aspect	Potential Impact & Objectives	Management Requirement
		•
Community Development (including water and roads)	The Community Development Plan aims to bring local communities, government, businesses, and other stakeholders together to identify challenges and opportunities faced by local communities and to propose solutions to address them in a sustainable manner. As a result, the Community Development Plan is closely linked with, and will enable the implementation of the Project's other Social Management Plans. In addition to the mitigation commitments outlined above, the Project will commit to an annual financial contribution to community development activities (i.e. Community Development Fund), and to providing technical and managerial expertise to guide investment, and will look to its partners to make similar contributions (financial, in-kind, or otherwise). The objectives of the Community Development Plan are to: • Participate in a forum and community driven process to identify, design, implement, and monitor community development strategies and activities; • Provide an overarching mechanism for the Project to better deliver and build upon social mitigation commitments; • Support local and regional government to better understand household livelihoods; and • Encourage all groups – including women, outsiders, youth, and other vulnerable and/or marginalised groups to fully participate in development planning and benefits.	*Impacts and Enhancement* The Community Development Plan refers to the population and community change impacts and economic and employment impacts identified in the social impact assessment section. It is a mandatory requirement established by the 2014 Mining Code. The following enhancement measures are to be reflected in this social management plan: • Identify community needs and development opportunities; • Define a participatory approach that keeps into account the views of all the stakeholders, including vulnerable categories; • Work with permanent consultations forums of local and regional stakeholders to ensure a participative approach to decision making. *Communications* Participate in a Community Development Working Group as a sub-group of the Regional and Local Consultation Committees. The Community Development Working Group should include regional and local government representatives as well representatives from local communities and, in particular, representatives from vulnerable and/or marginalized groups. • Provide regular updates on the planning and implementation of community development activities; • Discuss any concerns and challenges; and • Identify any emerging concerns and future priorities. Participate in regular community workshops to present Local Land Use and Development Plans, development priorities, and to review any Project actions and contributions. *Local Development Plans* Support for building upon the Local Land Use and Development Plans to: • Support regional and local government to identify development priorities in a participatory manner that includes vulnerable and/or marginalised groups; • Identify potential resources according to development priorities – can include funding as well as in kind contributions; • Support local government to establish partnerships with other development and business actors to implement development priorities; and • Areas of intervention will include infrastructure; local governance improvements; natural resource management; agricultural production; health; education and training; housing quality; water and sanitation; and electricity, among other key areas. Establish clear criteria for any Project contribution to Local Development Plans. • Prioritise interventions that contribute towards Project Social Management Objectives and, in particular, minimise negative impacts (i.e. influx, artisanal mining, etc.); • Put in place a principle of cost-sharing to avoid dependency on Project resources and to encourage the participation of other stakeholders; • Prioritise Project support to those interventions that directly target vulnerable and/or marginalised groups; • Clearly communicate Project funding criteria and priorities to all local communities (ALDI); and • Communities within the ALII and ARI may be the target of specific initiatives but would not be eligible for Local Land Use and Development Planning support.

For the purpose of the ESIA a land use assessment was carried out by Dr. Dibi Hyppolite of 2D Consulting Afrique The following crops have been identified during the land use survey:

- Plantain;
- Cocao;
- Coffee;
- Rice;
- Corn;
- Taro; and
- Vegetables.

Cacao is often associated with y crops such as plantains, taro and cassava in the early years.

The Project covers a total area of 13,432.58 ha, of this area corps make out approximately 13%. A breakdown in the land use types are included in Table 11-10.

Table 11-7 Land Use Types

Land Use	Surface Area (ha)
Degraded/secondary forest	3,218.49
Riparian and gallery forest	140.28
Annual crops	302.49
Perennial crops	1,278.52
Settlements	352.34
Bare soil	301.01
Streams and water bodies	797.24
Grassland	781.24
Shrub savannah	1,784.67
Dense shrub savannah	887.27
Wooded savannahs	2,700.74
Sacred Forests	122.78
Cemeteries	109.35
Mining Infrastructure	2.49
Quarries and Artisanal Mining	527.93
Seasonally flooded areas	125.74
Total Area:	**13,432.58**

Because as significant amount of the agricultural activities are taking place as shifting agriculture a final survey will have to be undertaken to verify the livelihood restoration requirements.

11.7.2 Roles and Responsibilities

Yaouré will make appropriate organisational arrangements to undertake the activities outlined herein. This will involve the creation of an in-house Communities Department, led by an experienced Manager, with primary responsibility for the sound and sustainable social performance of the Project, along with all the mitigation commitments outlined herein.

More specifically, the Communities Department will lead the planning and implementation of the following programme areas:

- Stakeholder Engagement;
- Livelihood Restoration
- Grievance Management;

- Land acquisition and compensation;
- Influx Management; and
- Community Development.

In addition, the Community Department will coordinate the stakeholder engagement dimensions of the Recruitment and Procurement Programmes. Planning and implementation of these programmes, however, will be the primary responsibility of the Human Resource and Procurement Departments.

More specific organisational arrangements for the SEP and FLRP are provided in the appropriate section of each standalone document.

11.7.3 Monitoring & Evaluation

Monitoring and evaluation have the following general objectives:

1. Monitoring of specific situations arising from implementation, and of compliance with objectives and methods set out in the Social Management Plans (SMPs);
2. Evaluation of the mid- and long-term impacts of the SMPs on impacted household livelihoods, environment, local capacities, economic development, and settlement.

Monitoring and evaluation reference documentation include:

- Environmental Impact Assessment for the Project, including the baseline information, impact assessment and action plans presented herein;
- 2014 National Census;
- Ivorian laws and regulations; and
- Applicable World Bank and IFC Safeguard Policies.

The SMP will be a "living document," which will be updated regularly using the results of monitoring and evaluation activities. Thus, the results of the monitoring and evaluation activities will serve to guide the adaptive management of the SMP and the social environment of the Project Area.

The identification, monitoring, and participation of vulnerable and marginalised groups is of particular concern for the Project and all Project Monitoring and Evaluation activities will prioritise the inclusion and focus on these groups.

11.7.3.1 Monitoring

Monitoring will be carried out by Yaouré but with close participation from the Regional and Local Consultation Committees and various subcommittees and working groups. Together, the Project and the Consultation Committees will participate in the selection, design, and application of methods and indicators for monitoring.

The purpose of monitoring is to provide the Yaouré Committee and other stakeholders with timely and concise information that indicates whether the SMPs are on track to achieve their objectives.

Monitoring will be based on a number of key performance indicators, which will be in the form of:

1. Simple audit observations of done / not done, present / not present, achieved / not achieved, etc.;
2. Easily measured numeric indices suitable for trend analysis; and
3. Collective judgments of the affected people, as revealed by participative socio-economic survey.

With regard to point #3 above, Yaouré intends that a substantial proportion of monitoring will be participatory: i.e., that stakeholders contribute in determining what is important to monitor, either by themselves or with Company assistance, as well as the various methods and indices chosen for monitoring.

The monitoring will be linked to past surveys (baseline information) but will not use control areas. Where important baseline information is not available but a particular subject requires monitoring, the objective will be to identify any trends that emerge, year by year.

Monitoring is of necessity a long-term and potentially open-ended activity. Yaouré and the Committee will define end-points and goals, which once achieved will allow monitoring to drop to a low level in those domains, while maintaining focus on other, less-accomplished areas.

While the monitoring exercise will specify if SMP implementation is on time and having the intended consequence, the monitors will avoid evaluation. Yaouré will employ independent third-party experts for evaluation.

Yaouré will monitor both inputs and impacts, as follows:

1. Input monitoring will establish if agreed policy, procedure, rates, staff and other inputs were delivered on schedule and in the requisite quality. Examples include:
    - Schedule and implementation of negotiated agreements;
    - Organisation manning and operation;
    - Budgets of resources used in SMPs;
    - Recruitment of local workers;
    - Grievance number recorded and number resolved;
2. Impact monitoring will cover:
    - Social structures – e.g., formal social groups, neighbourhood networks for reciprocal help, family;
    - Economic status of local households, including vulnerable peoples – e.g., livestock holding, employment, non-agricultural enterprise, household assets;
    - Land use – e.g., cropland and pasture;
    - Availability of natural resources – e.g., potable water;
    - Cost of housing and other essentials in the area;
    - Access and use of public facilities – e.g., water supply, sanitation, health and education services;
    - Employment – e.g., loss and gain from Project, training/skills enhancement;

- Health of project impacted persons and host communities – e.g., nutrition of vulnerable peoples and children specifically, morbidity of prominent diseases;
- Public perception of the Project – i.e., judgments of the Project, prospects for place and community.

Monitoring data will be analysed on an ongoing basis by Yaouré and the Committee to ensure that:

- SMP goals and objectives are being met, and
- No unforeseen Project impacts have emerged

Project monitoring will continue for the life of the mine with technical reports at varying frequencies plus an annual monitoring report released to the public. Annual reports notwithstanding, substantial task shortfalls, unintended negative consequences, or trends will be brought to the attention of Project management as they become apparent.

11.7.3.2 Evaluation

The general purpose of evaluation is to bring to the attention of the Project, the Community Committee, and other key stakeholders the following:

- Whether the SMPs are realistic (relevant, right-sized, and likely to meet appropriate goals, by means commensurate with those goals), timely, of requisite quality, and at sensible cost; and, if this is not the case, to propose course corrections;
- Any emergent or inadequately attended risks or problems; and,
- Any necessary changes in SMPs to better achieve Project goals.

To accomplish this purpose during rapid examination requires a high level of professional expertise in socio-economics, health, and resettlement.

Evaluation efforts should cover organisational capacity, state of the SMPs including progress with implementation and budget.

Specific objectives of evaluation are to provide assessments of:

- Level of compliance in implementation of the SMPs with relevant laws and regulations, Project policies, and relevant international safeguard policies;
- SMP impact on income and standard of living/welfare;
- Actions taken as result of monitoring to improve impact of the SMPs and to mitigate any negative impacts.

The evaluation is not primarily a paper evaluation effort. The majority of time of an evaluation mission will be in local communities observing how the affected people are faring, in terms of their productivity, health, vision of the present and future, and the strength of their social structures.

Independent third-party expert/s with experience in SMP implementation will do evaluation. The proximate purpose of each evaluation mission is a report of highest quality, provided in a unified draft before leaving the field. Each draft will be provided to the Project and to the Community Committee for comment. Each final evaluation report will become a public document.

In addition to the regular internal evaluations of the SMP, the Project has planned for two independent third-party evaluation missions: at 12 months and 24 months following initiation of construction activities.

In addition, the Project anticipates undertaking regular five yearly independent third-party evaluations of the SMP as legally required.

11.8 Financial Provision for Environmental and Social Management

Table 11-8 provides a summary of the financial provisions made for environmental and social management for the Yaouré project. These cost have been preliminary proposed by the Project and can be revised in accordance with community needs.

Table 11-8 Financial Provisions for Environmental and Social Management

Plan de Gestion	Activités	Cout	Durée
Engagement Parties Prenantes	Création et maintien de comités de gestion, suivi et évaluation des plans de gestion Planification des rencontres et des interactions avec les partenaires du projet (autorités gouvernementales et locales, communautés, autres acteurs)	<50,000 USD an	Tout au long du projet
Développement Communautaire	Planification et mise en œuvre de projets de développement communautaire	0,5 % des chiffres d'affaires	Pendant la phase d'exploitation minière
Gestion de l'Afflux	Création des structures/camps pour les travailleurs de la Mine Création des structures pour la gestion centralisée des recrutements	< 100,000 USD	Tout au long du projet
Exploitation Minière Artisanale	Support aux activités du gouvernement pour la régularisation de l'orpaillage illégal Reconversion des activités illégales en activités économiques durables	< 80,000 USD	Tout au long du projet
Participation a l'Economie Locale	Création des bases de données pour l'emploi et les opportunités d'affaires Organiser des ateliers pour développer les compétences requises des chercheurs d'emploi Organiser des ateliers pour identifier et évaluer les entreprises locales	<40,000 USD	Tout au long du projet
Restauration des Moyens de Subsistance	Acquisition permanente des terres Projets d'accompagnement pour la restauration des moyens de vie (formation, projets agricoles, etc.) Suivi et Evaluation des conditions de vie	>1M USD	Acquisition de terres à compléter avant le début des opérations et programme d'accompagnement / suivi pour 2-4 ans

11.9 Health, Safety and Environmental (HSE) Policies

The HSE policies, which have been updated and are applicable to the Project, are listed below, whilst the complete policies are included in Appendix 3. The following HSE policies are available for the Project:

- *Corporate Environmental Policy PML-ENV-POL-001*. This policy contains the Company's commitment to the protection of the environment. To this effect the Company will:
  - Comply with and where possible exceed the requirements of relevant legislation and other legal obligations for which we are accountable.
  - Identify environmental impacts in all business planning exercises and implement appropriate controls to minimise the associated business risks.
  - Make sufficient resources available to meet our environmental objectives, including effective and sustainable closure upon completion of activities.
  - Develop, implement and continually improve environmental management systems to ensure that environmental processes are integrated into all business units within the organisation.
  - Ensure all employees and contractors understand their individual environmental management responsibilities and increase their knowledge through ongoing environmental education and training.
  - Contribute to the protection of biodiversity in our areas of operation.
  - Communicate honestly and consult openly on our activities with all relevant stakeholders to ensure transparency with respect to environmental performance.
  - Maintain a high degree of emergency preparedness to effectively respond and recover from any environmental incident.
  - Put effective controls in place to prevent the pollution of groundwater, surface waters, soil and air and to minimise impacts on fauna and vegetation.
  - Ensure suitable waste management practises are achieved through established reduction, re-use, recycling and correct waste disposal strategies.
  - Introduce initiatives to reduce water and power consumption in order to preserve our natural resources and minimise our Greenhouse Gas emissions.
  - Implement effective systems to address the environmental risks of transporting, storing, handling and disposal of hazardous materials.
  - Monitor environmental performance through audits, workplace inspections and environmental sample analysis to identify issues and opportunities for continual improvement.

- Corporate Occupational Health and Safety (OHS) Policy PML-OHS-POL-001.The commitment of the Company contained in this policy include:
  - Provide a workplace that is conducive to effectively managing occupational health and safety.

- Fulfil, as a minimum, all statutory health and safety and other requirements including employer "duty of care" obligations.
- Seek to continually improve our occupational health and safety performance by utilising available technology, knowledge and management practises.
- Identify health and safety hazards and implement related risk controls to ultimately eliminate workplace injury/illness across the organisation.
- Develop, implement and continually improve health and safety management systems to ensure that safe work practices are integrated into all business units within the organisation.
- Educate, develop and endeavour that all employees and contractors have the appropriate skills and knowledge, understand their obligations and are held accountable for their area of responsibility.
- Make sufficient resources available to meet our occupational health and safety objectives.
- Review, audit and evaluate the health and safety performance of company operations and seek opportunities for enhancement.
- Provide safety leadership to effectively communicate and consult on safety issues with all stakeholders.
- Maintain 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 hazardous materials.

- Corporate Social Development Policy v1 PML-SOC-POL-001. In terms of this Policy the Company 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.

Yaouré Gold Project Waste Management Plan (WMP) – dared February 2015. The main commitments of the WMP are included in Table 11-4.

12 CLOSURE AND REHABILITATION PLAN

A conceptual closure and rehabilitation plan for the Project has been compiled. This has been included as Appendix 20 (Social Management Plan) and Appendix 33 (Closure Plan) to the ESIA.

12.1 Closure Goals

Based upon the general targets, discussed in the Conceptual Closure and Rehabilitation Management Plan (Appendix 33 to the ESIA), more specific goals have been defined. The following is based on the goal setting checklist (ICMM Integrated Mine Closure Toolkit, Tools 7-9) and was discussed with the ESIA Committee in May 2015.

The goals are structured according to the following:

1. Government stakeholders (National and Country level);
2. Perseus (company level); and
3. Communities (local level).

Table 12-1 Closure and Rehabilitation Goals

Level of responsibility	Area of concern	Goals
Government	Sufficient capacity (human resources, financial resources) must be available by the end of the mining Project to make active use of the assets that the Yaouré Project will have left behind	Government to develop structures and capabilities to optimally use infrastructure left behind, at Government's expense Government must put the necessary mechanisms in place to release the rehabilitation fund for remediation purposes
	Involvement and empowerment of local communities in the conceptual preparation and implementation of national and regional development programmes	Ivorian Central Government to provide communities with financial and human resources to actively participate in development programmes and make optimal use of infrastructure developed by Yaouré
Community/Region	To whom should land be given back? Which community entities or individuals should use it?	Rehabilitated land should be returned as per legal requirements at the time of closure, land-use restrictions may apply in certain areas (TSF, WRD)
	What are preferred post-closure land use scenarios?	Preferred post-closure land-use is agriculture
	What plans do the communities have for after-use of rehabilitated areas?	Define crops so that soil cover and possibly fertility can be optimised
	How can transport networks (roads, tracks) be maintained to serve socio-economic development, without destroying vulnerable habitats?	Land-use should be restricted to land that is already modified, no pristine areas. Restored mining land (including covered waste rock dumps) should be preferably used for agriculture Communities need support (financial, human resources) from Government to make use of the infrastructure
	How can health and educational infrastructure developed by Yaouré under the Community Development Plan be maintained? Who should do this? NGOs? Government? What structures could Yaouré help to put in place that can be taken over when mining is over?	Communities to work with Regional and National Government to prepare them for continued operation and maintenance of infrastructure Communities need support (financial, human resources) from Government to make use of the infrastructure
	Project infrastructure that is not	Responsibilities for maintaining infrastructure should

Level of responsibility	Area of concern	Goals
	removed after closure but left in place for community use: how can it be maintained after closure?	be assigned in communities People should get training to operate and maintain wells properly Develop plans to ensure that continuing funds are available to pay for repairs, such as charging small amounts for water use
	Requirements regarding surface water	Yaouré to ensure no polluted runoff reaches rivers However, Yaouré has no control over ASM and other activities that may be a source of water pollution (e.g., cyanide, mercury, turbidity, zinc, etc)
	Which livelihood and income streams that Yaouré helps develop (businesses, trade, craftsmen, agriculture/supplies etc.) can be kept up? How can this be done?	Businesses that thrive during the mining Project should look beyond the Yaouré Project for a wider basis of customers and markets Yaouré may also be able to assist with new/additional customers prior to closure
	How can employment be kept up, using the qualification levels developed in the mining Project? Craftsmen, mining experts, service providers etc. What will ensure best employability post-mining?	Work with Yaouré to define qualification requirements during and after the mining Project, establish additional training needs for post-closure phase and arrange for training Communities need support (financial, human resources) from Government to make use of the infrastructure
	What should be done to protect biodiversity post-mining?	Roads of the mining operations (haul roads, access tracks etc.) that would allow uncontrolled access to vulnerable habitats should be closed off and regraded Support from the Government is required to effectively enforce biodiversity protection measures
	Safe environment, no environmental and health/safety risks from closed infrastructure	Remove or render safe all mining infrastructure
	What competencies will the mine employees have developed that will be needed for closure and post-closure activities?	Develop skills matrix of Yaouré employees and assess for closure and post-closure requirements
	How can these competencies and qualifications be developed during the mine life cycle so that they are readily available when the mine closes?	Develop gap analysis (qualifications/skills required by Yaouré vs. qualifications/skills required by local businesses at the time of closure and post-closure)
	How can Yaouré develop its purchasing strategy to help local businesses develop during the mine life and at the same time diversify so that they can survive after the mine has closed?	Develop purchasing strategy adapted to local purchasing opportunities Encourage local businesses to adapt to Yaouré's needs, but also to be self sustaining beyond the needs of the company Develop longer-term supply contracts if possible
	Long-term stability of closed site	Post-closure provisions in the Community Development Plan Sufficient funds to cover environmental liabilities in the post-closure phase (e.g., closure fund)

The closure goals at national, community and company level cannot be considered in isolation, rather they are intimately linked and responsibility is shared. It is important to note that collaboration at all levels (government, community, company) prior to closure is essential to ensure that detailed plans and budgets are prepared in order to implement these goals, and that local communities require government support. Table 12-2 details shared responsibilities for key closure goals.

Table 12-2 Shared responsibilities for closure goals

Goal	Responsibility		
	Government Level	Community Level	Company Level
After-use of infrastructure by communities	Provide human and financial resources to communities	Define needs and develop plans for sustainable after-use	Leave assets behind Identify and inventories assets that can be handed over to community or government to manage (i.e. mine clinic, roads etc.)
Qualifications, skills, employability	Facilitate micro-loan schemes if possible Extend development programmes to Yaouré Project area	Use opportunities of building a healthy business environment during operation phase	Develop local businesses by a thought through purchasing and training strategy throughout mine life
Environmental Protection	Enforce environmental legislation in Protected Areas	Ensure local businesses develop in an environmentally friendly way	Leave behind clean environment without environmental liabilities

Table 12-3 from Appendix 33 summaries the closure and rehabilitation goals of Yaouré as follows:

Table 12-3 Summary of closure and rehabilitation goals of Yaouré

Area of concern	Goals
Land ownership and land use	Work with communities to agree post-closure land use and ownership
Infrastructure maintenance (roads, wells, buildings, health and education facilities)	Hand over infrastructure "as is", with maintenance plans developed as appropriate
Safe environment	Adequate structures for post-closure water management (sufficient design criteria with respect to return periods of storm events) Minimisation of water pollution (ground and surface water) Geotechnical stability of waste facilities Make people aware of use restrictions areas (e.g., TSF)
Biodiversity	Natural re-vegetation growth based on sufficient return of top-soil which would eventually (many years later) establish new habitat, that can easily turn to restoring natural habitat
Employment and social welfare	Preparing people for post-Project economy by sufficiently broad qualification
Economic development	Optimise purchasing policy to build sustainable local business base Integration of rehabilitated site into regional development plans
Visual appearance	Blend rehabilitated areas into surrounding environment

12.2 Requirements for Closure and Rehabilitation

Most of the requirements for closure have been addressed in Section 6 of the Addendum. The main requirements for closure and rehabilitation are included in Table 12-4. A risk assessment will be carried out at the time of mine closure to ensure that the main risks are identified and that these risks are managed as part of the closure and rehabilitation process.

Table 12-4 Summary of main requirements for closure and rehabilitation

Mine Area and Infrastructure	Closure and Rehabilitation Measures
Open pit	• Pit and benches slopes will be stabilized where possible as pit will not be back-filled • A bund of appropriate base width and height will be constructed from non-acid generating waste rock around the perimeter of the open pit for safety reasons (approximately 6,000m

Mine Area and Infrastructure	Closure and Rehabilitation Measures
	long) • The bund will be vegetated to assist with the stabilization of the bund • The closure and rehabilitation plan will be updated prior to closure to ensure that the best use is obtained.
In-pit water	• During closure, a pit lake will form • Current pit water quality monitoring suggests that the water quality is unlikely to be of concern • An ongoing waste characterization program during operations will allow further prediction of post-closure water quality • If this concludes any differently, appropriate measures will be taken to prevent access to the pit lakes.
Waste Rock Dumps (WRDs)	• During operations, WRD will have stable slope angles, however, if not maintained, sufficient countermeasures (e.g. regrading, buttressing, lowering of dump height) will be applied following a geotechnical assessment • A 0.2m thick soil or oxide material cover will be implemented to prevent erosion, it is expected that vegetation will be established (also improving visual appearance of WRD post-closure). • WRDs will be progressively rehabilitated during operations. • Cover test plots may be set up as part of covers on waste rock and tailings under progressive rehabilitation, or as separate trial sites. • Whether the soil cover can be used for agricultural purposes will be decided when the post-closure land-use is agreed with the communities. • Where necessary, additional erosion protection measures such as silt fences will be adopted. • Test work indicates that potential for acid generation is low and metal leachability of elevated elements is unlikely to be significant. Any potentially acid generating (PAG) material will be encapsulated by NAG material. • Monitoring of seepage water quality will provide quantitative input for future water management during closure and post-closure and will be used to update the Closure Plan during operations. • Water drainage ditches will be installed as part of operational water management, with diversion and collection ditches for erosion protection of the cover as required during closure, based upon a hydraulic assessment. • Ditches will require maintenance (cleaning, de-silting) during and post-closure. • No buildings or other structures with deep foundations should be erected on the cover, as this would damage the cover and compromise its function of minimising infiltration and oxygen ingress. Local communities should be made aware of this restriction. This should also be included in the handover agreement between Yaouré and the Government, in order to limit Yaouré's liability.
Ore Stockpiles	• Under planned operational conditions, the economically viable ore stockpiles will be processed prior to decommissioning of the Process Plant and site closure. • In case of unplanned/premature closure, ore stockpiles will be covered in the same way as WRDs
Tailings Management Facility (TSF)	• Tailings beach will be contoured through a strategic deposition plan in the last few years of the LOM • A 0.2m thick layer of soil material will be placed once tailings has consolidated, followed by re-vegetation, reducing erosion, supporting vegetation and improving visual appearance • Majority of seepage recovered through embankment internal drainage system and will reduce significantly at closure with no pond present. • Small supernatant pond to be removed by pumping and treatment, if required, prior to discharge. • The clean water retention dam, upstream of the TSF, will be filled with tailings during the final year of processing, also capped with 0.2m topsoil. • Channel to be created to spillway if required to avoid ponding. • Spillway to be protected with vegetation and rock to minimize water velocities and erosion.

Mine Area and Infrastructure	Closure and Rehabilitation Measures
	• Continued geochemical test work throughout the operations phase on the tailings and monitoring of the groundwater under the waste facilities and down-gradient will be used to update the closure plan and inform treatment requirements for water. • No buildings or other structures with deep foundations should be erected on the tailings cover. Local communities should be made aware of this restriction. This should also be included in the handover agreement between Yaouré and the Government. The ASM community in the area will be made aware of the very low residual gold content and a ban on re-processing should be included in the handover agreement of the mine site. • More specific rehabilitation goals are developed in a consultative process with the local communities in order to ensure that the post-closure end state is compatible with land use requirements. It must be noted that agricultural use of the closed TSF may not be desirable. Any use of covered waste surfaces may damage the cover and ultimately lead to its failure. Water quality of the ponds may not be suitable for any use. Therefore, access to waste surfaces should be discouraged where possible, e.g., by planting thorny or dense shrubs around the perimeter.
Tailings Pipeline and Water Return Pipeline	The proposed pipelines between process plant and TSF are 4km long: • Pipeline will be flushed to remove any loose tailings, wastewater will go into TSF • Pipeline including foundations, silts etc. will be removed • Narrow strip of the pipeline route to be re-integrated into the environment • Embankments flattened and cuttings backfilled so blend into environment where necessary • Pipeline corridor (2m wide) to be covered with soil layer of 0.2m to support vegetation • Pipe may be sold / re-used, dependent on residual wall thickness or disposed of.
Lined Ponds	• Residual water will be removed and treated prior to discharge • Peroxide to be used for cyanide detoxification • Volume of water dependent upon season, but will be minor with respect to TSF supernatant • Ponds will be left on site for fish breeding or similar activities by community, provided that during consultation meetings closer to mine life, it is confirmed that there is: – A substantial interest by the community in keeping the ponds after closure; – A credible concept and proof of economic viability of such after-use; and – The consent of the authorities to the intended after-use and acceptance of the ponds remaining in place. • If ponds are to be removed following consultations, closure plan to be updated.
Processing Plant	The process plant includes workshops, laydown areas, crusher, mill, leach circuit and administrative buildings and covers an area of approximately 9 ha. Closure and remediation activities will include: • All working areas will be demarcated for community and worker safety purposes • Decontamination of all potentially contaminated areas will be undertaken by specialists • Flushing and cleaning of reagent tanks, and cleaning and removal of any spills and contamination • Contaminated liquids and solids will be dispose on the TSF or suitable alternative • All plant equipment will be disassembled • Concrete bases will be removed up to a depth of 1m and disposed of appropriately • Soils associated with all removed infrastructure footprints will be removed up to a depth of 1m if not contaminated (if contaminated then 1m below the contamination level) and disposed on the TSF. A soil investigation needs to be done on potential contaminated areas during closure.
Camps	• Drinking water and Sewage treatment plants may also be included. • Permanent, fixed camp buildings and ancillary buildings (mess, recreation rooms, stores) are assumed to remain on site for use by the Government. • A clear handover procedure will be agreed closer to closure.
Explosive storage magazines	• All explosives will be disposed of appropriately (eg.returned to the supplier) • The explosive storage magazine will be removed during the closure phase

Mine Area and Infrastructure	Closure and Rehabilitation Measures
Site roads	• Haul roads that will not be used during aftercare and maintenance will be ripped and graded • A 200mm soil layer will be applied to assist with revegetation • After closure the rest of the internal haul roads will be ripped, graded and soiled • Re-aligned access road from Kouakougnanou to Angovia will be retained for public use
Landfill Cell	• The landfill cells for on-site storage of non-recyclable waste will be closed according to industry standards • Hazardous wastes cell will be rehabilitated in line with good international practice and local requirements
Vehicles and Mobile Plant Equipment	• Vehicles and mobile plant equipment will be sold or scrapped if they are no longer needed for remedial measures, depending on their remaining useful life.
Soils	• Soil stockpiles, including from historic Angovia mine, will be used for soil layers in closure of above facilities. • Closure plan, Soil Management Plan and Biodiversity Management Plan give guidelines on soil placement and revegetation procedures.
Biodiversity Restoration	• Revegetation using nurse crops and seeds/saplings from local plant nursery (establishment of a nursery can form part of the community investment and development programme) • De-silting of streams, removal of redundant culverts • Ripping of access tracks where possible, returning to forest • Monitoring up to 5 years post closure including close monitoring of any threatened species and bio-monitoring of offset areas to ensure success of established habitats • Working with local communities, authorities, other organizations to ensure continued protection of offset areas • Ecosystem Services – ensuring return of provisional services or at least offset of services are continued and maintained.
Water Management & Treatment	• Conventional water treatment installations from operations phase will be used in early closure phase to treat streams with high pollutants • If required, passive or semi-passive systems will be preferred to treat streams such as seepage from TSF over extended periods post-closure. The requirement for this will be confirmed through additional testing and monitoring throughout the life of mine. • Sediment control (silt settling ponds) will continue into post-closure period. • Erosion protection is through revegetation.
Socio-economic	**Closure Management Measure**
Consultation	Ongoing community consultations will be used to inform the precise details of the closure plan, as detailed above.
Capacity Building	With a view to long-term capacity building, during the operations phase the project will: • Optimise purchasing policy to build sustainable local business base (see Procurement Plan) • Facilitate access to technical and financial business development services and training • Provide skills upgrading programmes and/or apprenticeships for local area youth or Project staff (see Recruitment Plan, Livelihood Restoration Plan, Community Development Programme) • Ensure that skills training is sufficiently broad to prepare people for post-Project economy • Support local education initiatives • The above initiatives, combined with many others described in the Social Management Programme will provide long-lasting positive impacts and transferrable skills for the community post-closure.
Community Development & Assets	• During the lifetime of the project, Yaouré will work with local stakeholders to support the development of community infrastructure and services • The assets left behind by Yaouré after closure, i.e., roads, buildings, and ponds may be taken over by the government for continued use. • An inventory will be developed towards the end of the mine life including type of asset,

Mine Area and Infrastructure	Closure and Rehabilitation Measures
	location, approximate value, approximate useful residual life and requirements for continued maintenance. • A strategy will be developed for handing over these assets and programs.
Alternative livelihoods	During the lifetime of the project, Yaouré will work with local stakeholders to: • Identify alternative viable livelihoods • Provide demonstration of the viability of livelihoods, focused on agriculture or vocational training through the Livelihood Restoration Program and Community Development Program
Employment	Local employment throughout *closure* period will include: • Utilization of local nurseries to provide seeds, saplings and nurse crops for revegetation. • Unskilled manual labour jobs associated with decommissioning • Community monitoring programmes through the established networks and grievance procedures
Education & Awareness	An awareness raising and education programme will be implemented prior to closure, in order to educate the community with respect to: • Access and use restrictions of the rehabilitated sites; • Residual risks (e.g., steep slopes) and safety issues (pit wall, TSF, water quality, WRDs, etc.); and • "Dos" and "Don'ts" in the former mining area (distribution of easy-to-understand handouts to all families and multipliers). • Target Groups include teachers, parents, children/pupils/students, artisanal miners, farmers and other groups that intend to use the rehabilitated land.

12.3 After-care and Long-term Measures

Post-closure inspections/monitoring and stewardship are likely to be required in the following areas:

1. Inspections and TSF safety assessments, including inspections for soil erosion on the rehabilitated areas;
2. Inspections and safety assessments of waste rock dumps;
3. Inspections of all rehabilitated areas to confirm the establishment of sustainable vegetation. Where needed, initiation of corrective measures (re-seeding or re-planting of failed vegetation);
4. Habitat monitoring;
5. Water monitoring in the water bodies affected by mining to ensure no unacceptable point-like or diffuse discharges of polluted water are taking place;
6. Subject to results of water monitoring: treatment of effluents until acceptable water quality has been reached; and
7. Inspections of drainage ditches and associated water management features (passive water treatment systems, TSF, etc.).

The Best Practice Reference Document (BREF) for the Management of Tailings and Waste Rock (MTWR 2009) provides the guidance detailed in Table 12-5 for inspections and stability assessments of the TSF and waste rock dumps.

Table 12-5 Proposed assessment regime of TSF and waste rock dumps (from EU Best Practice Reference MTWR 2009), closure and post-closure period

Assessment type	Frequency		Personnel
	Tailings	Waste rock dumps	
Visual inspection	Half-yearly	Half-yearly	Operator
Geotechnical review	Yearly	Every 2 years	Qualified engineer
Independent geotechnical audit	Every 5-10 years	Every 5-10 years	Independent expert
Stability assessment, SEED (Safety Evaluation of Existing Dams)	15 – 20 years	-	Team of independent experts

The given frequencies for the after-care phase are relevant for the initial period after closure. Based on the assessment results, the frequency may be decreased with time to an extent that inspections, audits/reviews are no longer necessary if restoration is properly completed.

Inspections will also include erosion of embankment and waste slopes, particularly after heavy rainfall. Ditches, culverts, water diversion channels and similar structures will be regularly inspected and cleaned/repaired where necessary.

13 DIFFICULTIES AND GAPS

The ESIA is based on data available up until April 2015. A series of assumptions had to be made regarding technological parameters, such as footprints, emissions or wastes. The resulting uncertainties and gaps will be reduced or closed as development of the Project progresses.

Closure planning relies on assumptions regarding after-use of the rehabilitated sites. Community preferences may change over time. Closure planning will be updated as the end of the mine life draws closer.

The integrity of the impact assessment is not considered to be significantly compromised by these uncertainties and knowledge gaps. The conclusions regarding impacts and mitigation/management measures are sufficiently robust.

14 REFERENCES

Adou Yao, C.Y., N'Da, D.H., Bakayoko, A., Kouassi, K.E., N'Guessan, K.E. and L. Aké-Assi (2011). Distribution, regeneration and conservation status of Nuxia congesta in Côte d'Ivoire. Am. J. Sci. Ind. Res., 2(5):774-785.

Allaby, M. (2010) A Dictionary of Ecology, Oxford University Press, Oxford.

PERSEUS Mining Plc, April 2014: Technical Report and Preliminary Economic Assessment of the Yaoure Gold Project, Côte d'Ivoire. London.

Perseussinghe, M.D. and Bunting, S. (2008) Ecosystem processes, functions, services and human well-being. Accessed on 30.06.14 from http://www.enaca.org/modules/news/article.php?article_id=1781.

AMC (2013) Technical Report and Mineral Resource Estimates (NI 43-101 Report)

AMEC (2005) Angovia Heap Leach Project, Côte d'Ivoire, site visit report

AMEC (2014). Biodiversity and Ecology: Strategic pre-Scoping Study, Yaoure Gold Project. Report submitted to Perseus Mining plc.

Australian and New Zealand Environment and Conservation Council "Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration" September 1990

Australian Government (2008) Emission Estimation Technique Manual for Combustion Engines Version 3.0 June 2008

Australian Government (2012) Emission estimation technique manual for Fugitive Emissions. Version 3.1, January 2012

Basel Convention and UNEP. undated. Implementation of Decision VIII/1 on Côte d'Ivoire. Available at: http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/leaflets/270508.pdf (Accessed April 15 2015)

Basel Convention. Undated. Enforcement. Available at: http://www.basel.int/Implementation/TechnicalAssistance/Archives/Enforcement/tabid/2555/Default.aspx

Bitty, A.E., Gonedele Bi, S., Koffi Bene, J.C., Kouassi, P.K. and S.W. McGraw (2015). Cocoa farming and primate extirpation inside Cote d'Ivoire's protected areas. Tropical Conservation Science, 8(1): 95-113.

Boyd, J. & Banzahi, S. (2007) What are ecosystem services? The need for standardised environmental accounting units. Ecological Economics, Vol. 63(2-3), pp 616-626.

BS 7385: 1993 Evaluation and measurement for vibration in buildings: Part 2. Guide to damage levels from groundborne vibration. British Standards Institution.

BS 7445-1:2003 "Description and measurement of environmental noise. Guide to quantities and procedures" British Standards Institute

BS ISO 4866:2010 Mechanical vibration and shock – Vibration of fixed structures – Guidelines for the measurement of vibrations and evaluation of their effects on structures. British Standards Institution

BS 6472: 2008 Guide to Evaluation of human exposure to vibration in buildings. Part 2 Blast-induced vibration. British Standards Institution.

BS5228:2009-1+A1:2014 'Noise and vibration control on construction and open sites: Noise'. British Standards Institute

BS5228:2009-2 'Noise and vibration control on construction and open sites: Vibration'. British Standards Institute

Calculation of Road Traffic Noise (CRTN), 1988, UK Department of Transport

Campbell, G., Kuehl, H., N'Goran, P.K., and C. Boesch (2008). Alarming decline of West African chimpanzees in Côte d'Ivoire. Current Biology, 18(19): 903-904.

Churkina G, Trusilova K, Vetter M and Dentener F (2007). Contributions of nitrogen deposition and forest re-growth to terrestrial carbon uptake. Accessed at http://www.cbmjournal.com/content/2/1/5

Conradin, K. (2012) Sustainable sanitation and water management – the water cycle, SSWM, Accessed from: http://www.sswm.info/category/concept/water-cycle on 02.08.14.

Control of Vibration and Noise During Piling, a British Steel publication

De Groot, R.S., Wilson, M.A., Boumans, R.M.J. (2002) A typology for the classification, description and value of ecosystem functions, goods and services. Ecological Economics, Vol. 41 (3), pp. 393-408.

de Tessieres, S. 2012. Executive Summary. A National Survey of Small Arms and Light Weapons in Côte d'Ivoire. Arm control and Armed Violence Prevention before the Post-electoral Crisis. Small Arms Survey. Special Report 14. Available at: http://www.smallarmssurvey.org/fileadmin/docs/C-Special-reports/SAS-SR14-CoteIvoire-Summary-EN.pdf (Accessed 22 April 2015)

Department of Transport, Transport and Road Research Laboratory (TRRL) Report No. RR53 "Ground vibrations caused by civil engineering works" 1986

Design Manual for Roads & Bridges (DMRB), Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 7 HD213/11 – Revision 1, Noise and Vibration, The Highways Agency, Transport Scotland, Welsh Government and Department for Regional Development Northern Ireland.

Design Manual for Roads and Bridges TA 46/97: 'Traffic Flow Ranges for Use in the Assessment of New Rural Roads'

Design Manual for Roads and Bridges TD 42/95 'Geometric Design of Major/Minor Priority Junctions'

DWA (2008) Wetland and Riparian Delineation Guidelines 2008.

Eller, B. M. (1977). Road dust induced increase of leaf temperature. Environ. Poll., 13, 99-107

Fabio P., Njifonjou O., Assienan J., Kodjo A., Ndia Y., Salvati N., Seghieri C., Profil de pauvreté des communautés riveraines du lac de Kossou en Côte d'Ivoire (novembre 2002). Cotonou, Programme pour des Moyens d'Existence Durables dans la Pêche en Afrique de l'Ouest, 90p. PMEDP/RT/17. P29-30.

Fan, S.-M., S.C. Wofsy, P.S. Bakwin,. and D.J. Jacob, 1990: Atmosphere-biosphere exchange of CO2 and O3 in the central Amazon forest. Journal of Geophysical Research, 95, 16851-16864

Farmer A M (1993). The effects of dusts on vegetation – a review. Environmental Pollution, 79: 63-75

Fischer, F. (2004). Status of the Comoé National Park, Côte d'Ivoire and the effects of war. Parks, 14(1): 17-25.

Government of Australia, Chief Scientist, 2009, Which plants store more carbon in Australia: forests or grasses? http://www.chiefscientist.gov.au/2009/12/which-plants-store-more-carbon-in-australia-forests-or-grasses/ (accessed on 07 May 2015)

Government of United States of America. 2014. Côte D'Ivoire. Department of State. Available at: http://travel.state.gov/content/passports/english/country/cote-divoire.html (Accessed 20 April 2015)

Grantz D A et al. (2003). Ecological effects of particulate matter. Environment International, 29: 213-219

Guidelines for Community Noise (1999). World Health Organisation (WHO); Geneva

Harbaugh, A. W. 2005. MODFLOW-2005. The US Geological Survey Modular Ground-Water Model – the Ground-Water Flow Process. US Geological Survey Techniques and Methods 6-A16

Heitz Tokpa K, Kaufmann A, Zanker, F. 2015. The Ebola Outbreak in Comparison: Liberia and Côte d'Ivoire. Giga Focus. Number 3. Available at http://www.gigahamburg.de/en/system/files/publications/gf_international_1503.pdf (Accessed 8 June 2015)

Hilson G. (2003) – The Socio-Economic Impacts of Articsanal and Small-Scale Mining in Developing Countries. Balkema: Lisse, Abingdon, Exton, Tokyo

Hope AS, Fleming JB, Stow DA, Aguado E (1991). Tussock tundra albedos on the north slope of Alaska: Effects of illumination, vegetation composition, and dust deposition. J. Appl. Meteorol. 30, 1200–1206

IFC (International Finance Corporation) (2012). Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. Washington: World Bank Group.

Institute of Environmental Management and Assessment (1993) 'Guidance Notes No. 1: Guidelines for the Environmental Assessment of Road Traffic'. Horncastle: IEMA.

International Finance Corporation (2007) Environmental, Health and Safety Guideline: General EHS Guidelines – Environmental. Air Emissions and Ambient Air Quality. http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

International Finance Corporation (IFC). 2012. Guidance Note 4. Community Health, Safety and Security. Available at: http://www.ifc.org/wps/wcm/connect/e280ef804a0256609709ffd1a5d13d27/GN_English_2012_Full-Document.pdf?MOD=AJPERES (Accessed 24 February 2014)

International Labour Organisation (ILO). 2012. Ratifications for Côte d'Ivoire. Available at: http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11200:0::NO::P11200_COUNTRY_ID:103023 (Accessed 16 April 2015)

International Labour Organisation (ILO). 2013. Côte d'Ivoire 2013. Occupational Safety and Health (OSH). Available at: http://www.ilo.org/dyn/legosh/en/f?p=14100:1100:0::NO::P1100_ISO_CODE3,P1100_YEAR:CIV,2013 (Accessed 16 April 2015)

International Monetary Fund (IMF). 2014. Côte D'Ivoire. Fifth Review Under the Three-Year Arrangement Under the Extended Credit Facility and Requests for Modification of Performance Criteria and Extension of the Current Arrangement – Staff Report and Press Release. Available at http://www.imf.org/external/pubs/ft/scr/2014/cr14163.pdf (Acessed 8 June 2015)

Keller & Lamprecht (1995) Road dust as an indicator for air pollution transport and deposition: an application of SPOT imagery. Remote Sens. Env., 54, 1-12

Kruk ME, Rockers PC, Williams EH, Varpilah ST, Macauley R, Saydee G, Galea S. 2009. Availability of essential health services in post-conflict Liberia. Available at http://www.who.int/bulletin/volumes/88/7/09-071068/en/# (Accessed 8 June 2015).

LaSource SAS (1997) Projet de Developpement du Gisement d'Angovia, Etude de Faisabilité et de Mise en Exploitation

Lucole, S W & Dowding, C H "Statistical analysis of blast emission records from quarrying mining and construction operations in the State of Illinois" Illinois Institute of Natural Resources, Document 79/02, 1979.

MA (Millennium Ecosystem Assessment) (2005). Ecosystems and human well-being: opportunities and challenges for business and industry. World Resources Institute, Washington, DC, USA. Available at: http://www.maweb.org/documents/document.353.aspx.pdf

Mac Vicar et al.: Taxonomic Soil Classification System, 2nd edition (1991).

Malhi, Y., A.D. Nobre, J. Grace, B. Kruijt, M.G.P. Pereira, A. Culf, and S. Scott, 1998: Carbon dioxide transfer over a Central Amazonian rain forest. Journal of Geophysical Research, D24, 31593-31612.

Malhi, Y., D.D. Baldocchi, and P.G. Jarvis, 1999: The carbon balance of tropical, temperate and boreal forests. Plant, Cell and Environment 22, 715-740.

Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works: Series 600 Earthworks, UK Department of Transport.

Millennium Ecosystem Assessment (2005a) Ecosystems and Human Well-being – Biodiversity synthesis. Biodiversity Synthesis. World Resources Institute, Washington DC.

Millennium Ecosystem Assessment (2005b) Ecosystems and Human Well-being – Opportunities and challenges for business and industry. Biodiversity Synthesis. World Resources Institute, Washington DC.

MINAGRI, Rapport saison agricole et sécurité alimentaire 2014, Délégation de Bouaflé

Office of the High Commissioner for Human Rights (OHCHR). 2015. Analysis of eight Francophone African countries' national legislation on PMSCs. Report - Office of the High Commissioner for Human Rights. United Nations. Available at: www.ohchr.org/Documents/Issues/Mercenaries/WG/Legislation/MainReportFrancophoneAfrican.doc (Accessed 20 April 2015)

OSAC. 2014. Côte D'Ivoire 2014 Crime and Safety Report. United States Department of State. Bureau of Diplomatic Security. Available at: https://www.osac.gov/pages/ContentReportDetails.aspx?cid=15611 (Accessed 21 April 2015)

Pace, T (2005) Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10

Preventionweb. Undated. Côte d'Ivoire: National progress report on the implementation of the Hyogo Framework for Action (2013-2015) Available at: http://www.preventionweb.net/english/professional/policies/v.php?id=41074

PricewaterhouseCoopers (2010) Biodiversity and business risk – a global risks network briefing, World Economic Forum, January 2010.

Ramsar Convention (1971) Guide to the Convention on Wetlands, Ramsar, Iran, 6th edition

Republic of South Africa (2005), Department: Environmental Affairs: State Of Air Report: Chapter 3 Air Quality Standards and Objectives

RGPH - Recensement General de l'Habitat et de la Populaption (official census) (2014)

Rio Tinto (2012). Simandou Social and Environmental Impact Assessment Volume I: Mine. Chapter 23: Ecosystem Services.

Rodhe et al. (1988) Acidification and Regional Air Pollution in the Tropics in Acidification in Tropical Countries, Edited by H. Rodhe and R. Herrera 1988 SCOPE. Published by John Wiley & Sons Ltd.

Santosh K. P. (2012) Ecological effect of airborne particulate matter on plants. Environmental Skeptics and Critics, 2012, 1(1):12-22

SGS (2005) Audit Environnemental d'Etat des Lieux Mine Aurifière d'Angovia, Republique de Côte d'Ivoire

SGS (2006) Angovia Gold Project – Baseline Data Monitoring Programme

SGS (2007) Etude d'Impact sur l'Environnement du Projet Aurifière d'Angovia, Republique de Côte d'Ivoire

SGS, 2007: Environmental and Social Impact Assessment of the Angovia Gold Mine, Cluff Gold. Ghana.

Sherman, C.W., 1931. Frequency and intensity of excessive rainfalls at Boston, Mass. Transactions of the American Society of Civil Engineers, 95, 951-960.

Siskind DE, Stachura VJ, Stagg MS and Kopp JW "Structure response and damage produced by airblast from surface mining" USBM RI8485, 1980

Siskind DE, Stagg MS, Kopp JW and Dowding CH "Structure response and damage produced by ground vibration from surface mine blasting" USBM RI8507, 1980

Soro, G.E., Goula Bi, T.A., Kouassi, F.W and Srohourou, B, 2010. Update of Intensity-Duration-Frequency Curves for Precipitation of Short Durations in Tropical Area of West Africa (Cote d'Ivoire). Journal of Applied Sciences, 2010. Volume 10, Issue 9, Pages 704-750.

SRK (2008) Technical Review of the Angovia Gold Mine, Mount Yaoure, Côte d'Ivoire (NI 43-101 Report), 2008

Tano, Y. et al. (2007). Projet aurifère d'Angovia : Étude de la faune terrestre. Report submitted to Cluff Gold plc.

Tardy, Y. J., L. Novikoff, C. Roquid (1991), Petrological and Geochemical Classification of Laterites

TEEB (2010) The Economics of Ecosystems and Biodiversity - Report for Business – Executive Summary.

The Environmental Effects of Production Blasting from Surface Mineral Workings, Vibrock Report on behalf of the UK's DETR, 1998

The World Bank. 2015a. .Business Reforms in Côte D'Ivoire. World Bank Group. http://www.doingbusiness.org/reforms/overview/economy/côte-divoire

The World Bank. 2015b. Ease of Doing Business. Overview. http://www.doingbusiness.org/reports/global-reports/doing-business-2015 (Accessed 15 April 2015)

The World Bank. 2015c. Ease of Doing Business in Côte D'Ivoire. World Bank Group. Available at http://www.doingbusiness.org/data/exploreeconomies/côte-divoire (Accessed 15 April 2015)

Transparency International. Undated. Côte D'Ivoire. International Defence and Security Programme. Available at: http://government.defenceindex.org/sites/default/files/documents/GI-assessment-Cote-Divoire.pdf (Accessed 21 April 2015)

UK Environment Agency (2011) How to Comply with your Environmental Permit – Horizontal Guidance, Annex f: Air Emissions. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298239/geho0410bsil-e-e.pdf

UNEP (2008) Resource and Guidance Manual for Environmental Impact Assessments, available from http://www.unep.org/Themes/Freshwater/PDF/Resource&GuidanceManualforEIAs.pdf

UNESCO (2003) Convention for the safeguarding of the intangible cultural heritage UNESCO, Paris, available at http://www.unesco.org/culture/ich/index.php?pg=00002 (Accessed 20/04/2015)

United Nations Educational, Scientific and Cultural Organisation (UNESCO). 2010. Engineering: Issues, Challenges, and Opportunities for Development. UNESCO report. Produced in conjunction with:World Federation of Engineering Organisations (WFEO) International Council of Academies of Engineering and Technological Sciences (CAETS)

International Federation of Consulting Engineers (FIDIC) http://unesdoc.unesco.org/images/0018/001897/189753e.pdf (Accessed 15 April 2015)

United Nations Environment Programme (UNEP). Undated. Global Partnership for Waste Reduction. http://www.unep.org/gpwm/InformationPlatform/CountryNeedsAssessmentAnalysis/CotedIvoire/tabid/106545/Default.aspx

United Nations Office for the Coordination of Humanitarian Affairs (OCHA). 2011. Côte d'Ivoire: "We must not let the people of Côte d'Ivoire down". ERC Amos. Available at: http://www.unocha.org/top-stories/all-stories/c%C3%B4te-divoire-we-must-not-let-people-c%C3%B4te-divoire-down-erc-amos

United Nations Security Council (UNSC) 2014. Report of the Security Council mission to Liberia, Côte d'Ivoire and Sierra Leone, 18 to 24 May 2012. Available at: http://www.un.org/en/ga/search/view_doc.asp?symbol=S/2014/242 (Accessed 20 April 2015).

United Nations Security Council (UNSC). 2015. Conflict-related sexual violence - Report of the Secretary-General (S/2015/203) [EN/AR]. Available at: http://www.un.org/en/ga/search/view_doc.asp?symbol=S/2015/203

United Nations. 2015. Environment. Treaty Collection. Available at: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-14&chapter=27&lang=en

United States Environmental Protection Agency (USEPA) (2005). Managing Your Environmental Responsibilities: A Planning Guide for Construction and Development. EPA Office of Compliance. April 2005. Available at http://www.epa.gov/compliance/resources/publications/assistance/sectors/constructmyer/myerguide.pdf (Accessed 25 April 2014)

US Environmental Protection Agency (USEPA) (2003-2011) AP-42. Compilation of Air Pollutant Emission factors. http://www.epa.gov/ttnchie1/ap42/

US Environmental Protection Agency (USEPA) (2013) Non-Road Compression-Ignition Engines, Exhaust Emission Standards. Last updated 03/06/2013.

US Environmental Protection Agency, AP 42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, Section 13.2.2, Unpaved Roads, November 2006

Wischmeier et al. (1971) The Soil Erodibility Nomograph.

Wong, M.H. (2003) Ecological restoration of mine degraded soils, with emphasis on metal contaminated soils, Chemosphere 50, 775-780.

World Bank (2015), Cote d'Ivoire Dashboard Climate Future http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile&CCode=CIV&ThisTab=ClimateFuture. Accessed 25 June 2015

World Business Council for Sustainable Development (2011) Guide to Corporate Ecosystem Valuation – A framework for improving corporate decision making. Geneva.

World Health Organisation (2005) WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf

World Health Organisation (2014) Côte d'Ivoire. Global Health Observatory Data, http://www.who.int/gho/countries/civ/country_profiles/en/ (Accessed December 2014)

World Health Organisation (WHO). 2013. Liberia: Health Profile. Available at: http://www.who.int/gho/countries/lbr.pdf (Accessed 25 March 2014)

World Meteorological Organisation, 2006. Manual for Estimation of Probable Maximum Precipitation, Second Edition. Operational Hydrology Report No. 1, WMO No. 332.

World Resources Institute (2011) Ecosystem Services Review for Impact Assessment – Introduction and Guide to Scoping, Washington DC.

World Resources Institute, Country Greenhouse Gas Emissions: Côte d'Ivoire http://cait2.wri.org/profile/Cote%20d'Ivoire (accessed 11 May 2015)

WRI (World Resources Institute) (2011). Ecosystem Services Review for Impact Assessment – Introduction and Guide to Scoping. Washington, DC, USA.

WRI (World Resources Institute) (2013). Weaving Ecosystem Services into Impact Assessment. Technical Appendix, version 1.0.

15 APPENDICES