SISSINGUE (TENGRELA) GOLD PROJECT

UPDATED ENVIRONMENTAL AND SOCIAL IMPACT STUDY

FINAL REPORT

March 2016

Prepared by

PERSEUS MINING CÔTE D'IVOIRE

SISSINGUE GOLD PROJECT (TENGRELA)

UPDATED ENVIRONMENTAL AND SOCIAL IMPACT REPORT

Final Report

Prepared by:

CECAF International

March 2016

Preamble

Le Cabinet d'Etudes, Conseils d'Assistance et de Formation (CECAF) International thanks the staff of Perseus Mining, including Perseus Mining Ivory Coast, the local authoritieweek in Tengrela (Prefect Tengrela, Deputy Prefect of Kanakono), the elected officials, managers, heads of villages in the Project Area, and all of the villagers for their hospitality and the information they provided. Their information contributed to the success and the achievement of the environmental and social impact study for the Sissingue gold project.

We express our deep gratitude to the following members of the Perseus Mining Group and Perseus Mining Côte d'Ivoire, including:

- **Jeff Quartermaine**, Managing Director and CEO of Perseus Mining;
- **Adam Smits**, Project Director;
- **Georges de Gersigny**, Managing Director of Perseus Mining Côte d'Ivoire;
- **Diarra Yacouba**, Deputy Director and Co-ordinator of Government Relations
- **Chantelle De La Haye**; Group Sustainability Manager

We would also like to express our gratitude to **TANO Kokra Alphonse**, of Perseus Mining Côte d'Ivoire for his contribution and assistance during various visits for this study.

We would also like to thank everyone who has contributed to this study and whose name has been inadvertently omitted.

TABLE OF CONTENT

LIST OF MAPS

LIST OF PHOTOS

LIST OF TABLES

ABBREVIATIONS

ANAC : Civil Aviation Authority

ANDE : National Environment Agency (Agence Nationale De l'Environnement)

ANCOLD : Australian National Committee on Large Dams

BER : Office of Study & Design

CIAPOL : Ivorian Anti-Pollution Centre (Centre Ivoirien Anti-Pollution)

CIL : Carbon-in-Leach

COMINE : Interministerial Mining Commission (Commission Minière Interministérielle)

DA : Directorate of Agriculture (Direction de l'Agriculture)

DD : Sustainable Development (Développement Durable)

DGE : Directorate General of the Environment (Direction Générale de l'Environnement)

DH : Directorate of Hydrology /Water **(**Direction de l'Hydraulique)

DRE : Directorate of Water Resources (Direction des Ressources en Eau

DDM : Directorate of MininG Development (Direction du Développement Minier)

DGMG : Directorate General of Mines & Geology (Direction Générale des Mines et de la Géologie)

DOIR : Department of Industry & Resources (Australia)

EIES/ESIA : Environmental & Social Impact Assessment

ESS/HSE : Occupational Health, Safety & Environment

GCW : West African Endemic Species (Espèces Endémiques Ouest Africaines)

ICOLD : International Committee on Large Dams

OCG : Occidental Gold

OIPR : Ivorian Parks and Reserves Office (Office Ivoirien des Parcs et Réserves)

ONEP : The National Office of Drinking Water (Office National de l'Eau Potable)

PDR : Displacement and Resettlement Plan (Plan de Déplacement et de Réinstallation)

PGE-A/EMP : Environmental Management Plan

PIA : Interested and Affected Parties (Parties Intéressées et Affectées)

PNAE : National Action Plan for the Environment

POI : Internal Operations Plan (Plan d'Opérations Internes)

PPP : Public Participation Process

PR : Exploration Permit (Permis de Recherche)

RACI : Ivory Coast Aeronautical Regualtions (Règlement Aéronautique de la Côte d'Ivoire)

SFI : International Finance Corporation (Société Financière Internationale)

SOMICI : Ivory Coast Mining Society (Société Minière de Côte d'Ivoire)

TDR/TOR : Terms of Reference

TSF : Tailings Storage Facility

UN : United Nations

WB : World Bank

WHO : World Health Organisation

WSF : Water Storage Facility

EXECUTIVE SUMMARY

I RATIONALE AND IMPORTANCE OF THE PROJECT

In October 2014, Perseus Mining Limited (Perseus) engaged Lycopodium Minerals Pty Ltd (Lycopodium) to coordinate a Definitive Feasibility Study for its Sissingue gold project (the Project), located north of the Ivory Coast.

The study is based on previously published reports and includes new contributions from resources within Perseus and other focus groups.

The Sissingue Gold Project, formerly known as the Tengrela Gold Project, is located in northern Côte d'Ivoire, near the border with Mali and about 700 km north of the business capital, Abidjan. The nearest town is Tengrela, about 15 km west of the limits of the concession. Korhogo, the main regional center, is 150 km south-east.

The Sissingue deposit is located within the project area Tengrela, located in the greenstone belt of Syama-Boundiali. The rocks found in outcrops and boreholes mainly include sediment Isoclinal folds (sandstone, mudstone and conglomerate side) of the supergroup Birimian, interpreted as units of turbidite flows towards the north northeast, sinking deep west.

The mining method provided for the operation is a conventional excavation of open pit with waste rock. The pit will be accessible via a transport route that is 20 m wide, angled at 10% and has two lanes. At the bottom of the pit, the final levels will be accessible by single lane ramps.

A total of 5.5 Mt of ore reserves at 2.4 grams of gold was estimated on 1 February 2015. The full life of mine has been scheduled in monthly periods. Plant production begins during the sixth period and varies from 60 to 100% of capacity over a period of three months.

The processing plant and the tailings are located on the east side of the open pit of Sissingue, just outside the blasting perimeter. The camp and airstrip are located south / southwest of treatment facilities. The wastewater treatment plant (WWTP) is located 1 km northwest of the camp.

The discharge of mining waste will surround the Waste Rock Dump. A compacted clay area for mining waste will be built in the upstream (internal) portion of the Waste Rock Dump. Within this high traffic area, is a clay structure, which has been subject to geotechnical investigation and whose characteristics are able to contain the residues and minimize infiltration leaks. In addition to clay, smooth geo-membrane of high density polyethylene (HDPE) which complies with the required international standards will be put under the supervision of a qualified subcontractor.

II INSTITUTIONAL AND REGULATORY FRAMEWORK

The legal framework makes reference to the principle of the human right to the environment, as well as the strict sense of laws in terms of environmental protection and mining.

The legislative and regulatory context regarding the environment is mainly based on the following texts:

- Law No. 96-766 of 3 October 1996 of the Environment Code including its implementing regulations;
- •Decree No. 96-894 of 8 November 1996 laying down the rules and procedures for studies related to the environmental impact of development projects;
- Decree No. 2005-03 of January 6, 2005 on Environmental Audit;
- Order No. 00972 of 14 November 2007, on the application of Decree No. 96-894 of 8 November 1996 laying down the rules and procedures applicable to studies on the environmental impact of development projects;
- Order No. 00973 of 14 November 2007 on the application of Decree No 2005-03 of 6 January 2005 on Environmental Audit.

Given the importance of the gold project, other laws and regulations are essential. All laws and regulations applicable to the project are indicated in the sub chapter 1.3.

Côte d'Ivoire established environmental regulatory structures on June 8, 1971. There have been many changes and names, but there has been an increasing interest in the protection of the environment.

Therefore, the Ministry for the Environment was created and with it, several administrative and essential legal structures including: the Directorate General Environment (DGE), the Ivorian Anti-Pollution Centre (CIAPOL), the Ivorian Parks and Reserves Office (OIPR), the National Agency for the Environment (ANDE), the Department of Forestry, the Department of Water Resources (DRE) and the Natural Resources Department.

To extend its activities for the territory, the Ministry for the Environment has brought together the services for the population by creating Regional Directorates.

For this project, the Ministries involved are:

- the Ministry of Environment and Sustainable Development
- the Ministry of Mines and Industry with the General Directorate of Mines and Geology and Interminsterial Mining Commission (COMINE) charged with approved the documents submitted for the granting of the operating license;
- the Ministry of Agriculture with the General Directorate of Rural Development;

- the Ministry of Construction and Urban Planning including the Town Planning Department, the Construction Department;
- the Ministry of Urban Safety and Sanitation;
- Ministry of Economic Infrastructure with the General Directorate of Water Supply, the National Office of Drinking Water (ONEP), the Road Management Agency (AGEROUTE);
- the Ministry of Water and Forests with the Water Resources Department;
- the Ministry of State, Ministry of Interior and Security;
- the Ministry of Health and Public Hygiene;
- the Ministry of Animal Resources and Fisheries.

III DESCRIPTION OF THE INITITAL STATE OF THE SITE

i Physical Environment

The project area, located in the north of the Ivory Coast has a tropical or Sudanese climate, with two seasons. The wet season is from mid-April to late October and the dry season from November to mid-April. During the wet season, maximum rainfall amounts occur from July to September with a maximum (370 mm) in August and rainfall between 1000 and 1600 mm. The dry season is characterized by high temperature variations, permanent haze, low cloud cover and the almost total lack of rainfall during the months of December, January and February.

The Harmattan creates some disruption during the dry season, but the effects are not as sensitive to the diurnal amplitude of maximum temperatures. The amplitude of the average maximum temperature is higher (3.3 ° C) while the minimum values do not vary significantly.

Evaporation is very important during the dry season with a peak in January (255 mm), which corresponds to the presence of the harmattan. In contrast, it is lower (<80 mm) during the wet season.

The average relative humidity varies between 31 and 77%, with a minimum in December and January and a maximum of June to September. The amplitude of the minimum values is significant. Indeed, these values vary from 18 to 61.7%. In contrast the maximum values remain consistent throughout the year with average values of 83%.

The maximum and minimum mean monthly wind speeds are 3.1 m/s respectively (11.16 km / h) and 2.1 m / s (7.56 km / h). The area and the two access roads to the site are entirely rural. There is no industrial source of air pollution with the exception of diesel emissions. However, each year the harmattan winds spread the region with huge amounts of fine dust particles. This seasonal pollution, although specific to this geographical area of the continent, occurs during the dry season, from December to March. During this period, it is not unusual to have days when air particle concentration exceeds the standard set by the World Health Organisation (WHO) which is 500 micro-grams of dust per cubic meter of air (500 g / m3).

The pollution from fine particles of dust is mainly caused by transport equipment on unpaved roads and has not reached an alarming threshold. All values obtained are around the level of 1000 mg / m2

/ day limit between weakly polluted environments (≤ 1000 mg / m2 / day) and those that are highly polluted (> 1000 mg / m2 / day).

The results of the analysis of chemical pollutants (TVOC, CO, SO_2 and H_2S) illustrated by Table 3.10, show that the levels of pollutants recorded both at the operating site and in the surrounding villages are extremely low. The air quality in relation to pollutants is excellent and meets the air quality standards and health protection in accordance with WHO limits and EH40.

The environment of the study area is quite noisy during the day between 8 am and 6 pm, but the high noise levels are generally below the threshold of 70 dB (A). These levels are produced by noise from motorcycles, cars and other trucks. In some localities, this noisiness continues up to 8 pm. The highest values recorded from 8 am to 8 pm in different localities are between 60 and 80 dB (A).

Beyond 8 pm, the levels are generally low with values close to 50 dB (A). The recorded maximum values are above those proposed by the World Bank (55-70 dB (A)) and the Ivorian regulation (40-60 dB (A)). However, these noise levels do not occur continuously. The nights are relatively quiet with sound levels around 50 dB (A). Moreover, those obtained in the localities of the operating site during the same period are between 40 and 58 dB (A). In the localities of Basso and Border Ivory Coast-Mali, the noise levels may continue past 9 pm with values between 70 and 80 dB (A).

The surface water in project area has different characteristics in both seasons. PH values are weakly basic (7,23-8.5). Moreover, the concentration of total suspended solids (170 mg / l) obtained in the Pourou dam during the dry season is higher than the discharge standard (50 mg / l) indicated by the World Bank. This favours an increase in turbidity (215 NTU) at this station. The concentrations of COD (<25-100 mg / l) and BOD_5 (<5 mg / l), are below the World Bank threshold values, which are 250 mg / l, respectively for COD and 50 mg / l for BOD_5. Surface water is substantially free of trace metals in addition to iron (0.6 - 9.1 mg / l), manganese (0.04 - 0.16 mg / l) and aluminum (0.22 - 9,7mg / l).

The groundwater is characterized by hardness and low mineralization, with a pH close to neutral. These waters have low concentrations of nitrate and traces of nitrite. The majority of heavy metals in the samples analyzed are in trace amounts. Only iron, manganese and aluminum were measured, but in low concentrations, always below the WHO drinking water standards.

The analysis of the microbiological quality of groundwater revealed contamination of well water in the project area. Groundwater contamination sources can be different. WHO standards require the complete absence of germs in drinking water.

Compared to the surface water, the groundwater is of better quality and is suitable for consumption in terms of quality guidelines for drinking water (WHO standards). Surface water is exposed to pollution that could be important given its greater use for human activities.

In the current state, there is moderate organic pollution in relation to microbiological pollution. Overall, it is weakly mineralized with concentrations of dissolved salts and relatively low conductivities.

Analysis of the flow gauging stations of the area shows a single peak in September.

The average annual flow of the Bagoé Papara is 33.11 m3 / s with a specific rate of 0.0037 m3 / s / km2. At Kouto, the annual average flow of 42.76 m3 / s with a specific flow rate 0.009 m3 / s / km2.

The Bagoé river has several hydraulic structures that facilitate the flow of surface water. In addition, there are two agro-pastoral Dams (Pourou and Kanakono) in the project area.

The main uses of the river are domestic and semi industrial by miners. The project area has many sacred water issues related to religions practiced by the people of the region.

Outside the dry season surface water is commonly consumed by those not aware of the risks of waterborne diseases users.

Granite formations occupy most of the area. Geological formations in the project area date back to the lower Proterozoic period. They are essentially derived from the Eburnean granitisation and basic plutonic.

The well-known alteration profile obtained is the result of a long and complex external geodynamic process involving:

- a shallow layer of humus surface soil that serves as support to the plants;
- alterite clay.

These granite formations are very poor aquifers because the hydraulic conductivity (permeability) is very low. However, they play an important role in the underlying power draining fractures. The rocks are predominantly red lateritic clays and laterite breastplates, the granitic granular sand, multi transition zone and fractured bedrock.

In total 60 phytoplankton taxa were identified (45 taxa in the dry season and 30 during the wet season). The class of Conjugatophyceae is best represented with 23 taxa. The least represented class is the Dinophyceae species.

B6 and B8 stations have a higher species richness, each with 24 species. Sixteen (16) species were collected during the wet season and 29 species in the dry season. There are some missing samples from the wet season.

Only four species of phytoplankton in the Bagoue river are associated with eutrophic conditions. Those are:

- Pandorina morum
- Duplex Pediastrum
- Eudorina elegans
- Navicula cuspidate

This is an indication that the sampled environment is not polluted.

Transparency and temperature are abiotic parameters that would influence more diversity of phytoplankton. The structure and development of phytoplankton are also influenced by inputs of nutrients due to urban and agricultural effluents, which are an indirect cause of the rich phytoplankton of some rivers.

Zooplankton obtained consists of 12 compounds taxa:

- Three (3) copepods:
  - Thermocyclops decipiens

  - Thermocyclops sp.
  - Mesocyclops sp. and nauplii
- six cladocerans:
  - Diaphanosoma excisum
  - Ceriodaphnia cornuta
  - Moina micrura
  - Moinodaphnia sp.
  - Alona sp.1
  - Alona sp.2, ostracods and chironomid larvae

Six (6) taxa were sampled in the wet season:

- Thermocyclops decipiens
- Mesocyclops sp.
- Ceriodaphnia cornuta
- Alona sp.1
- Alona sp.2
- Chironomid larvae

While five (5) taxa were inventoried during the dry season:

- Thermocyclops sp.
- Nauplii
- Moina micrura
- Moinodaphnia
- Ostracods

Only Diaphanosoma excisum was harvested during the two sampling periods.

During both periods, 6 benthic organisms in three taxonomic groups (insects, millipedes and maggots) were identified in the sampled stations. The insects include 3 larvae of Culicidae (each represented by an individual) and Chironomidae (n = 3): a centipede, an oligochaete include the Myriapods and worms.

With the exception of Chironomidae collected only during the wet season, other taxa were sampled during the dry season. The low diversity of this fauna could be explained by the sandy substrate of Bagoue river, which is incompatible to the development of these organisms due to high porosity.

A total of 57 fish species distributed in 17 families and 37 genera were identified. Families that have the highest diversity of speciese are those of Mormyridae and Mochokidae with respectively 11 and 10 species. They are followed by the Cichlidae (n = 7), Cyprinidae and Alestidae each with 5 species. Other families include between 1 and 3 species.

There is an influence of the season on the ichtyologique settlement in Bagoé. There are 11 species in the list of species sampled in the dry season. This inlcudes

Brienomyrus Niger, Hippopotamyrus psittacus, Mormyrops anguilloides, Petrocephalus Bane, Alestes baremoze, Heterobranchus longifilis, budgetti Synodontis, Synodontis catfish, Synodontis sorex, Hemichromis bimaculatus and Tilapia guineensis.

In addition, 20 species found in the dry season were not sampled in the wet season. The number of Mormyridae harvested fish species (n = 11) during the present analysis indicates better quality of aquatic environments.

All these data suggest that the aquatic environment of the Bagoé remained well preserved. However, like all trans boundary rivers, due to its location in several states, it has different currents and protections from one bank to another.

Quantitative analysis showed that 1008 individual fish with a total mass of 23045.49 g were collected during this study. In the dry season, 548 individuals belonging to 46 species were recorded. This population is numerically dominated by Brycinus leuciscus (n = 63), Brycinus nurse (n = 62), Petrocephalus Bane (n = 58) and Schilbe intermedius (n = 51). In the same season, there was a total mass of 9897.49g recorded. The Brycinus nurse (n = 1408g) Brycinus macrolepidotus (n = 1048g), Synodontis shawl (n = 788) and Tilapia zilli (n = 506) specias are the most important. B8 station (Kanakono) is the richest station in individual fish (n = 251) and the largest in the weight class (p = 4360g).

During the wet season, 460 individual fish with a total weight of 13148 g were sampled. Numerically the Petrocephalus Bane (n = 65), Hippopotamyrus psittacus (n = 63), Brycinus nurse (n = 46) and Schilbe mandibularis (n = 42) species are the most important. Relative to their weight the species Marcusenius senegalensis (n = 2554g) Hippopotamyrus psittacus, Brycinus nurse (n = 1160), Petrocephalus Bane (n = 1017g) and Schilbe mandibularis (n = 1052g) dominate the population.

BA1 station Sissingue is the richest in individual fish (n = 170) and has the largest number and weight (p = 5132 g).

ii Biological Environment

Soil genesis depends on several factors including, regional climate, topography, parent material and type of vegetation. The soil survey included the mining perimeter and project area (250 m on either side of the axis) of the two roads by which it is accessed, from Tengrela. The terrain has little contrast; it is a set of plateaus with armored buttes at the top.

The network of natural drains is very loose. It consists of several tributaries of the Bagoue River, which border the perimeter in its northern part and along which is a flood plain, which is relatively wide in some areas. The natural vegetation is the savannah, with very sparse woods.

The main types of landscape in the study area are divided into three (3) sets following the topographical middle sequence. These include the moderate slopes formed by several hills and slopes, gentle slopes formed by ridges and flood zones. The hydrographic network consists of tributaries of the dry Bagoé outside of the wet season.

Nine (9) major habitats have been identified on the project site including:

1. woodlands

2. gallery forests
3. wooded grassland
4. shrublands
5. savannah woodland
6. grassland
7. ponds
8. lakes
9. fallow and crops

The study of flora identified 417 plant species belonging to 269 genera and 84 families.

The most represented genres are: Ficus (12 species), Combretum (9 species), Hyparrhenia and Panicum (6 species each).

The most diverse families are those of the Poaceae (62 species), Fabaceae (32 species), Euphorbiaceae (28) Caesalpiniaceae (20) species), Combretaceae and Rubiaceae (17 species each).

The most predominant species of the site are:

- Baissea multiflora (29 records)
- Lannea acida
- Parkia biglobosa with 24 records each

Among the species recorded, two (2) were reported as West African endemic species (GCW). These are Anthostema senegalense (Plot 4) and Moghania faginea (Parcels 2 and 13) according to the lists of Ake-Assi (2001; 2002). The flora of the project site is relatively poor in endemic species.

Many uses are associated with the plants collected on the project site. There are either medicinal plants or food crops picked for other uses. The population of the project site, for the most part, uses on the local traditional medicine. A total of 57 species used in the preparation of traditional medicines have been identified. In addition, 23 species used as food plants were counted.

The types of small and large mammals are specific to two types of habitats. One species (Praomys rostratus) was captured in the forest and two (Dasymys incomptus and Tatera valida) were captured in the Savannah. The species Praomys rostratus (n = 10) is the only representative of forest mammals in the study area. Small mammals in open environments are represented by two species (Tatera valida, n = 7; Dasymys incomptus, n = 1). Other mammals such as the African straw Dogfish (Eidolon helvum) and Herison Atelerix albiventris were observed.

Seventeen of the 139 species of birds including sixteen native to the Ivory Coast and Africa who were not observed during the first study phase (dry season), were identified in the second phase (wet season). Also, it was noted that 24 species of birds observed in the dry season were not inventoried in the wet season. It was noted that in addition to three species endemic to West Africa (the dinghy parrot Poicephalus senegalus, the Turaco Musophaga violacea purple and yellow-crowned gonolek Laniarus Barbatus) inventoried in the dry season, the Waxbill Estrilda caerulescens vinegar tail was also observed in the study area.

Soil formation is characterized by two evolutionary processes at the Tengrela mine perimeter: redesign and induration. They affect the upper part of the majority of soil exposed areas and hydromorphism is a consequence.

Redesign and induration led to a slowdown in the vertical dynamics of the water, considering the flatness of the topography. The consequences of these processes are agriculturally quite strong and are reflected primarily through low installation depth, especially an accentuation of mechanical erosion as a result of tillage (silt is more dominant in the grain size).

The mining perimeter covers an area of 44,600 hectares. In total 1219 farms exist on this mining perimeter. These farms cover a total area of 4 895.18 hectares. This represents a rate set value of 10.98%.

The rest of the area is covered by fallow, bushland, wooded grassland and some pockets of forest. Bushland dominates the project area. The savannah, estimated to be about 3649 hectares, on the mining perimeter is under strong pressure from farmers who engage in slash and burn for the installation of plantations.

There is 448.56 hectares of forest remaining on the perimeter.

The farming system is manual and uses mainly family labour and carts with oxen. The leftover from the original natural vegetation is burned.

During the wet season, food crops (maize, sorghum, peanuts, etc.) are sown in the goal of helping to cover the food needs of the family. There is a range of various vegetable crops (peppers, okra, eggplant, etc.) and during the wet season cashew seeds are planted.

iii Human and Socio-Economic Environment

Tengrela is located in the north of the Ivory Coast. It is bounded to the north, east and west by the Republic of Mali, to the south by Kouto (Boundiali); south-east by Korhogo and in the southwest by Odienne. Tengrela covers an area of 2200 km2 and has 3 sub-prefectures (Tengrela, Kanakono, Débété), 6 towns including 4 rural communes, 5 rural counties whose main cities are Bolona, Néguépié, Débété, Zanasso and Papara, 49 towns and 195 settlements. According to data of the General Census of Population and Housing (RGPH) of 1998, the population is estimated at 63 644 inhabitants. The main economic activities in Tengrela are:

Agriculture: it is the main activity practiced by the population (75.42% of the total population). There are three major types of agricultural production systems:

- manual production for market gardening and food crops such as millet, sorghum and rice;
- Production with horses; used for cotton, corn and peanuts;
- motorized production, mainly with tractors in growing cotton, corn and peanuts.

Roads: the main roads of Tengrela are unpaved. The main roads that connect to neighboring counties are Tengrela- Boundiali road (120 km), the Tengrela M'bengué-Korhogo road (160 km), the Tengrela Goulia- Odienne road (200 km).

Telecommunications:

Telecommunication services are provided by the Côte d'Ivoire Telecom company and mobile phone operators (Orange, MTN, Moov, Koz). Radio and national television communication are received regularly at Tengrela level. Mail delivery is not ensured in Tengrela since September 2002.

Water supply and electricity:

Société de Distribution d'Eau de Cote d'Ivoire (SODECI) and the Ivorian Electricity Company (CIE) supply Tengrela with water and electricity respectively. In Tengrela, only 6 localities have electricity.

Markets:

Tengrela includes five markets covering 5 locations.

Education:

The education service in Tengrela is organized around primary and general secondary education. At the level of primary education, Tengrela has forty six (46) establishments including thirty six (36) that are functional.

Non-functional facilities:

(10) lack teaching staff. There is an institution for secondary and technical education.

Harnessing natural resources includes fishing. Fishing is done in the traditional way on the Bagoue and Mahandianabani rivers. The use of fishery products from these streams, due to their geographical position, is done by the people of Tengrela and Malian communities. To a lesser extent, fishing is done on lakes of some agricultural dams in Tengrela (Lomara, Néguépié).

Housing: The housing in the project area is very diverse. In general, depending on the construction materials, there are five main types of houses: houses in geo mounted concrete with earth (41%), the permanent houses (19.15%), houses in clay (20.16%), the concrete houses geo mounted with cement (18.36%) and huts (1.45%). The project area housing is quite modern.

The collected archaeological remains belong to the Middle to Upper Pleistocene and post-Quaternary periods. A relative chronology based on the morpho-technical and typological characteristics of the lithic tools demonstrate the representation of cultural periods such as Acheulean complex sangoens, Middle Stone Age (MSA), the final Paleolithic (for Paleolithic), the Neolithic and ancient iron metallurgy (for the post-quaternary) whose practice on all cultural areas in Ivory Coast is no longer in doubt (Guédé Y. 2003).

This study revealed a cultural diversity of prehistoric times in this region and contributes significantly to the enrichment of the national archaeological collection.

Tengrela has fourteen (14) health facilities, including two (2) that are non-functional. The"Boubacar Tengrela" Infirmary is the only private facility care. Several local and international NGOs (Action Against Hunger, Health Alliance International), community-based organisations and UN agencies (UNICEF, WHO, WFP, PUMLS) are also present. The pharmaceutical facilities consist of public facilities (Pharmacy of Tengrela General Hospital, Tengrela District Health Pharmacy) and private facility (Yacouba Sylla Tengrela Pharmacy).

The main causes of death are attributed to twelve (12) diseases: malaria, ARI, malnutrition, chronic diarrhea, skin diseases, anemia, typhoid, STD, TB, urinary schistosomiasis, Buruli ulcer and leprosy.

IV IDENTIFYING POTENTIAL IMPACTS AND PROPOSED MITIGATION AND COMPENSATION MEASURES

The environmental protection measures have been classified by the areas of environment in order to make a direct link with major potential impacts. An estimate of the cost of these measures is also presented.

i Atmospheric Environemnt

The main sources of dust are explosions at the mine and the movement of vehicles on laterite roads. To limit the impact of these activities, the company has planned a series of measures, including:

- the use of such explosives breaking with a low blow, limiting projections of materials in use;
- limiting traffic speeds on all roads;
- regular watering by water tankers of the busiest roads.

The environmental conditions of the project area and the measures adopted will maintain the dust concentration in the air to acceptable levels. Dust levels will be measured regularly.

Cumulative impacts related to air emissions have been identified and are due to the construction of the wastewater treatment plant, the third crusher treatment process and the runway.

ii Noise and vibration

The only noise and vibrations that could be viewed from the site are the explosions related to work with explosives in ore extraction. These explosions will be brief and will take place at most once a day. They will be of low and medium impact as perceived by the communities in the project area. It should be noted that all high-use roads and especially the ore transport routes were planned to go outside residential areas.

To minimize the effect of surprise due to the noise of explosives Perseus Mining Ivory Coast has scheduled the broadcast of a program of information to the population. The population will know in advance the hours when the detonations could be heard.

In addition, photos will be taken before the first explosions to have information relating to structural conditions of the buildings from the closes villages. Thereafter, periodic monitoring of these buildings will be made.

iii Preservation of drinking water sources and the aquatic environment

The drinking water in the area will not be affected. The project provides for no effluent discharge which may contain cyanides or metals in small quantities, no water should become polluted. The impacts on the aquatic environment were considered minor, but a number of measures with an overall positive effect on the preservation of water resources in the region will be adopted by the company. They are :

- the quality of surface water and groundwater will be monitored regularly;

- preventive signs prohibiting the consumption of water will be installed near bodies of water which may accidentally contain cyanides;
- various civil works will be carried out to prevent any possible deterioration of hydrological and hydrogeological resources;
- Construction work will begin in dry season.

iv Ecological environment support measures

To limit the impact of the project on the ecological environment, a number of measures, with an overall positive bearing on the fauna and flora of the site, will be adopted. They include:

- deforestation of bushland sites will be selective and gradual. The wood obtained will be managed and delivered as firewood to local residents.
- the rehabilitation of the site as soon as possible;
- recovery, whenever possible, of topsoil for rehabilitation purposes;
- Inclusion in contracts of employees and subcontractors of a hunting ban clause over the entire mining area.

v Occupational Health and Safety of Mine Staff

Respect for health and safety is a major priority for Perseus Mining. These aspects will be carried out in accordance with regulations. To this end:

- employees will have personal protection based on the nature of their tasks;
- employees will receive appropriate training for their work;
- automatic warning devices will be installed at various points of the facilities;
- emergency care equipment and an infirmary will be available on the site.

Furthermore, the mine site has an airstrip located about 1 km from the processing plant. This signals the presence of relatively moderate level of air traffic in the vicinity of our study area.

The risk of a plane crash is higher during landing and takeoff. In addition to the areas covering the immediate vicinity of the airport, the risk of accidents are also higher in the corridors used for air traffic.

Security measures are proposed, including:

- maintenance and inspection of aircraft before takeoff;
- the establishment of a transport plan (flight schedule, safety rules, etc.);
- compliance with aviation regulations of the Côte d'Ivoire;
- maintenance of the airstrip;
- construction of the track in parallel to the facilities;
- emergency equipment;
- an emergency response plan.

vi Cyanide control

Cyanide control during operation is based on the following key points:

- compliance with regulations;
- security and monitoring of transport and the mine;
- safe use: safe transportation of solids, safe handling;
- specialization and training of personnel working on cyanides;
- Prevention of leaks: detection systems, retention, pollution control equipment;
- the establishment of alert procedures and emergency response prepared with the authorities.

vii Securing processing residues

Storage of ore tailings after gold mining will be carried out in a large dam enclosed by a breakwater. To ensure the security of this fam, the measures to be taken will include:

- the design of the dam will take into account past cases of ruptures;
- quality control procedures will be applied to the design, the work, the operation of the pool, its supervision and its after-closure;
- in the event of a rupture it will be studied and an action plan will be prepared with authorities to eliminate any serious consequence.

viii Socio-economic support measures

The positive impacts of the project should greatly outweigh the negatives. However, any development of this nature particularly in a relatively remote rural area can cause sometimes unpredictable situations. These can however be avoided if a regular and effective dialogue is held between all parties concerned. The impact assessment identified a number of issues and potential problems that must be addressed by the company before and during the operations phase.

The Joint Strategy will be the dialogue, consultation and negotiation with the authorities and all social partners:

- the company will ensure that all access to villages that have been blocked by the mine operations are properly replaced;
- Perseus Mining Ivory Coast will cover relocation costs of residents of hamlets in the area of mining operations and pay adequate compensation to anyone who has lost a field or plantation;
- Equal employment priority will be given to villagers of Sissingue and the people of the region;
- As a social partner, the company is committed to maintaining dialogue and constant contact with the authorities in order to monitor, prevent and possibly propose solutions with a view to development with communities;

- Perseus Mining Ivory Coast has noted the expectations expressed by the population in the investigations and consultation meetings in the framework of this study;
- Finally, Perseus Mining Ivory Coast will ensure that local people are not prone to excessive disturbance of their environment. To this end, a regular program of monitoring environmental parameters will be set up.

V PRELIMINARY PLAN OF ENVIRONMENTAL MANAGEMENT

An environmental management and monitoring plan of a mining project is a practical document that must be updated continuously from the beginning of the construction period and during operation, and the rehabilitation of the site. In general, this support plan includes all activities and measures to be undertaken by the mining company to manage and control the state of the environment on site, coordinate the implementation of project mitigation measures, maintain ongoing communication with all parties involved (authorities, population, NGOs, etc.), prevent and manage potential accidents and rehabilitate the site.

The Preliminary Plan of Environmental Management has the following general structure:

Introduction

1. Perseus Mining Environmental Policy
2. Structure and organization of Sustainable Development Staff (DD)
3. Financial means
4. Project Description
5. Summary of impacts and compensatory measures
6. Environmental monitoring
7. Communication and community development programs
8. Waste management
9. Plan for rehabilitation and closure
10. Occupational Health and Safety
11. Emergency response plan
12. Audit Operations
13. Matrix Environmental Monitoring Plan

Perseus Mining recognises that its activities continuously interact with the environment. Therefore, it is committed to ensuring that all operations are conducted in a responsible manner in order to protect and promote the environment and the health and safety of its employees, contractors and social partners.

Its objective is to excel in the field of sustainable development, including environmental, health and safety (EHS) and communication. Each employee must actively support its policy and implement in accordance with the commitments of its environmental policy, health and safety and community relations.

The matrix of environmental monitoring plan includes a list of environmental actions to be performed for the duration of the project. This plan establishes environmental indicators for monitoring of project mitigation measures. Moreover, institutions that will be involved in this phase were identified as well as the costs for the environmental monitoring.

VI SITE REHABILITATION AND CLOSURE

A number of general principles of rehabilitation will be monitored to ensure that site remediation can meet the objectives and criteria defined below:

- preparation of a detailed rehabilitation and closure plan of the site in the first year of the deposits put into operation;
- rehabilitate the site progressively;
- prevent the introduction of plant or animal species that may be harmful nature;
- re-profiling low gradient logged areas to ensure their stability, adequate drainage to minimize erosion, an appearance consistent with the overall appearance of the site, and a surface that can be revegetated (or naturally re-colonized);
- identifying and managing risk areas that may develop long-term toxic properties;
- recover maximum topsoil for use in connection with site rehabilitation activities that will be carried out during operation;
- if the soil will not be available in sufficient quantity, identify and test substrates that will or may acquire similar properties;
- restructuring of the compacted surface horizons (scarify) to promote natural colonization of vegetation;
- maximise use of local plant species;
- dismantle and remove all the facilities that will not be required as part of a post-mining use and reinstatement, and non-mining waste end exploitation;
- monitor and manage the rehabilitated areas until the vegetation reaches sufficient maturity to not requiring a particular intervention;
- plastic waste will not be buried in landfill or soil, or also in the sterile land, but will be collected and recycled or incinerated if possible.

A preliminary estimate of the land surface will be changed by the construction and operation of a quarry, a Waste Rock Dump, an ore processing plant and its annexes, a TSF, a camp and access and transport routes.

The rehabilitation program will include rehabilitation of different areas. This includes:

- quarries ;
- waste Rock Dump;
- residues in the ground;
- the processing plant and its annexes;

- roads and other infrastructures to be cleared.

Perseus Mining has prepared a closure plan that will meet the terms of the mining agreement established as part of the operating license and the requirements of the Mining Code. At the end of production, the future of all buildings, vehicles, small infrastructure (eg fuel tanks), etc. depend on the terms of the mining agreement.

In general, the rehabilitation program of the site is funded at various levels. During the operating phase, the work (research, reshaping an area, etc.) considered necessary will be funded from operating budgets (mainly mining and environment).

The costs of closure and site rehabilitation has been estimated at 2,560 billion CFA francs. That does not include the management fee for the closing of the site and post-closure environmental monitoring. Costs will be determined on the basis of the figures obtained from modern mines established in the sub-region and will be in a period of partial or total closure.

To ensure coverage of the costs of rehabilitation, Perseus Mining will take out a bank guarantee, with a leading bank, located in Cote d'Ivoire or abroad, which will be implemented in the event of non-compliance by Perseus Mining of its obligations under the rehabilitation program of the site. The cost of rehabilitation and site closure will be determined on an annual basis and will be revised based on the evolution of mining activities and the level of achievement of the rehabilitation work performed by Perseus Mining during the operation phase.

VII HEALTH, SAFETY AND EMERGENCY RESPONSE PLAN

Like any industrial activity, the proposed project may have in exceptional conditions, malfunctions, which can be a source of incidents or accidents. These may relate to the safety or health of the operating personnel and the public, and the integrity of the natural environment.

The analysis of past accidents shows that they often result from the combination of primary events individually less serious and can have internal causes (mishandling, etc.) and / or external causes (lightning, earthquake, storm, etc.).

The goal of the company is to excel in the field of health and safety. Each employee must actively support its health and safety policy and implement it in accordance with the following commitments:

- provide a workplace that effectively contributes to the management of health and safety;
- complete a standard of health and safety including other mandatory care conditions;
- continually seek to improve occupational health and safety performance using the available technology, knowledge and practice management;
- identify the health risks and safety and implement recommendations to eliminate accidents and illness at work through an organization;
- develop, implement and continuously improve the health management systems and safety and ensure that the practices are integrated in all units of the company;

- educate and train all employees and contractors by providing knowledge causing them to be responsible in their area;
- have sufficient resources to achieve the mine health and safety goals;
- review, verify and evaluate the performance of health and safety during the operational period to make improvements;
- communicate and consult all stakeholders on security issues;
- maintain an effective emergency prevention system;
- implement effective systems to reduce or eliminate the risk to health and safety related to transportation, storage, handling and disposal of hazardous materials.

Perseus Mining is committed to taking all necessary measures to ensure the safety and protect the health of people working on site or located in its surroundings.

The emergency response plan includes a substantial section on alert procedures and emergency response. Perseus Mining will establish an emergency plan, which will be communicated to employees of the mine, to the authorities concerned (mining services, the environment and civil protection).

The plan's primary objectives are:

- monitoring and maintaining constructive and operational arrangements established to limit the causes and effects of accidents due to a failure of one of the works of the project. The environmental staff should be regularly informed of the results of the control and monitoring of these works. This will occur when measuring a particular environmental setting according to monitoring procedures;
- updated and repeated dissemination of alert procedures;
- updated and regular testing of the emergency response procedures.

Emergency situations or accidents will be classified according to their nature, severity and probability of occurrence. In the mining sector, accidents are often classified into 3 categories:

- **High risk**: serious accidents that result in death or serious injury of persons, material damage or a high level of environmental pollution outside facilities / structures;
- **Medium risk**: accidents that resulted in moderate to benign injury in people, property damage or environmental pollution either benign or inside facilities / structures;
- **Low risk**: accidents that resulted in minor injuries in persons, minor damage or a very localized environmental pollution and quickly controlled.

Procedures for intervention and alert will be developed as part of the emergency response plan, will include the following steps:

- verify and assess the severity of the accident (eg leakage, breakage, etc.);
- in the case of a leak, check whether it is confined to a holding area;
- sound the alarm and / or inform the head of the operational site (depending on the severity of the accident, the mine manager and the Director General shall be notified immediately);

- in the case of a leak, try to stop and / or direct it to an area where it will be contained;
- in case of pollution, clean up the site (eg with calcium hypochlorite if it contains cyanide);
- depending on the nature of the accident, to ensure that the employees or the public are not in danger (e.g. The users of water resources downstream of a leak must be warned and prevented from using this resource until the situation is under control should also provide an alternative water source).
- conduct an urgent investigation following an incident;
- prepare a written report to the managing director and head of department;
- inform the authorities of the concerned ministries (mining, environment, etc.);
- set up monitoring measures to ensure that the effects or consequences of the accident are under control;
- make technical changes or the training necessary to prevent a recurrence of the problem.

VIII PUBLIC PARTICIPATION

Article 39 of the Environment Code, Article 77 of the Mining Code and laws regarding Performance Standards of the International Finance Corporation on the environmental and social performance (April 2006) and the Equator Principles (March 2006), require that the proponent of a development project gives the opportunity to the public to be involved in decision-making regarding improving the quality of the environment.

Thus, stakeholders and members of the public who will participate in the evaluation process are listed as the interested and affected parties (PIA). The practice of disclosing information about the project and to meet with the PIA is known as the public participation process (PPP).

The public participation during the environmental and social impact assessment of the Sissingue gold project aims to create an environment of informed participation and be constructive for all concerned or affected by the proposed development.

The public participation process has the following objectives:

- identify all interested and affected parties of the project
- circulate accurate information about the project;
- gather information that will contribute to environmental and technical investigations;
- form partnerships and relationships that promote positive interactions between all parties;
- deal with all potential conflicts;
- take into account the concerns, problems and suggestions from the public and respond;
- manage the expectations of PIA;
- submit to the Ivorian and international requirements in terms of consultation.

Perseus Mining has adopted a consultative approach in which the PIA are actively involved. Thus, the problems and concerns taken into account during decision making for project options can be explored.

The information-sharing meetings between the authorities, the public and the community took place in January, February and May 2011. The purpose of these meetings was to inform stakeholders of the Sissingue gold project and gather all the information, expressed concerns or suggestions.

People's wishes are generally similar and relate to employment opportunities and development of socio-economic infrastructure in their respective village.

In general, people prefer community development projects that have a positive social and economic impact on their communities. Note that several of the claims made by those present at the meetings are directly linked to precarious conditions of their village, including lack of social infrastructure.

1.0 INTRODUCTION

1.1 GENERAL PRESENTATION

Under the Sissingue gold project, the mining company Perseus Mining Ivory Coast is committed to attaining an Environmental and Social Impact Assessment (ESIA) to comply with Ivorian regulations and international requirements.

This mandatory study will enable it to identify all the major environmental issues that will be generated by mining activities and which must be managed by Perseus Mining.

Perseus Mining has requested the Office of International Studies CECAF approved by the Ministry of the Environment and Sustainable Development of the Ivory Coast to complete this study.

1.1.1 Overview of Perseus Mining Côte d'Ivoire

The mining company Perseus Mining Ivory Coast is an established Australian company wholly owned by Perseus Mining Limited.

1.1.2 Overview of the consulting firm

CECAF International is the private consulting firm responsible for conducting environmental and social impact studies for clients or petitioners.

Ministerial Order No. 00559 of March 25, 2008 approved the environmental audits and related activities, as well as the completion of environmental and social impact assessments of development projects.

The team of experts in charge of conducting the study is presented in **Table 1.1**. below.

Table 1.1 Team in charge of the study

NAME	AREA	ACTIVITIESS
Gilbert GUEY/ TIEMELE Jacques Environmental Engineers	**Environment Manager**	Coordinate the activities of team members and drafting progress reports. Guiding the team members. Specifying the methodology to implement and organize
Mousso Fernand	**Geologist**	Study of the relationship between mining and the environment. Identification of potential negative impacts and proposed corrective measures. Demonstration of the entire project of the safety system.
Koukoualé Beugré	**Industrial risk**	Industrial safety study during operation of the works, development of an Emergency Plan
Dr KOUASSI Williams	**Hydrogeologist**	Study of groundwater levels and different supply sources (wells, boreholes etc)
Prof. GOULA Bi Tié Albert	**Hydrologist**	Study of the Bagoé River Basin catchment. Presentation of quantitative assessment of water resources in the project area
Dr COULIBALY Sandotin Lacina	**Sanitation**	Study of the waste on the site and description of the technical characteristics of the wastewater treatment plant
Prof. N'GUESSAN Edouard	**Plant specialist**	Inventory of flora and impacts of the project on plant communities
Prof. TANO Yao	**Wildlife specialist**	Inventory of wildlife and impacts of the project on wildlife communities
BENIE Joseph	**Health specialist**	Epidemiological study for the direct impact area of the project and highlighting the impacts on the local communities in relation to the sociologist
Prof. KOUAMELAN Essetchi Paul	**Hydrobiologist**	Characterization of the river, identification of pollution sources in relation to the hydrologist
Dr GOH Denis	**Social economist**	Survey to highlight the structuring of land in terms of activities (agricultural land, shops, markets, etc.) and operation of the entire land of Sissingue. Description, analysis and evaluation of the significance of project impacts on workers (construction phase) and mine personnel (operational phase) as well as the socio-economic activities at Sissingue in particular and the entire the region in general.
Dr TIE Bi Tra	**Soil specialist**	Description of soil types, estimated agricultural land potential, highlighting the potential for soil erosion
Dr GALA Bi Trazié	**Agronomist**	Inventory of agricultural crops
Dr. GUEDE Yiodé	**Archeologist**	Assessing the importance of identified archaeological sites
Gilbert GUEY Dr GOH Denis Dr GALA Bi Trazié	**Specialists in issues of mobility and resettlement**	Directing relocation and resettlement Compensating populations
BROU Doffou Jean-Jacques	**Cartographer**	Development of thematic maps for the study Development of the map summary for the study

1.2 PROJECT BACKGROUND OF SISSINGUÉ GOLD PROJECT

Exploration activities were conducted between 1998 and 1999 by Randgold. Between 2001 and 2002, Occidental Gold launched a mapping program of soil sampling, rock and wells to define a number of anomalies. The exploration was halted from 2003 to 2004 for reasons of social unrest.

In 2004 Perseus Mining Ltd (Perseus) found great interest in the Project. Since then, Perseus has started to target the significant anomalies, setting up a program covering several phases of drilling.

The Project area of Sissingue comprises two adjoining exploration permits, PR145 and PR146 respectively covering a total area of 876 km2. Mineralization has been found in the area of Sissingue- referred to as the Sissingue gold mine.

1.3 INSTITUTIONAL, LEGISLATIVE AND REGULATORY FRAMEWORK

1.3.1 Legislative and regulatory framework

The legal framework makes reference to the principle of the human right to the environment and the laws are strict regarding environmental protection and mining.

The legislative and regulatory context of the environment is mainly based on the following texts:

- Law n ° 96-766 of October 3 1996: the Environmental Code with its implementing regulations;
- Decree No. 96-894 of 8 November 1996 laying down the rules and procedures for studies related to the environmental impact of development projects;
- Decree No. 2005-03 of January 6 2005 on Environmental Auditing:
- Order No. 00972 of 14 November 2007, on the application of Decree No. 96-894 of 8 November 1996 laying down rules and procedures applicable to studies on the environmental impact of development projects;
- Order No. 00973 of 14 November 2007 on the application of Decree No. 2005 -03 of 6 January 2005 on environmental audit;
- Aeronautics settlement of the Ivory Coast (RACI) 4007, volume 1 on the Environmental Protection - Aircraft Noise;
- Aeronautics settlement of the Ivory Coast (RACI) 4007, volume 2, on environmental protection - Emissions from aircraft engines.
- Civil aviation isbased on the text below:
- Ordinance No. 2008-08 of January 23 on the Code of Civil Aviation.

Given the importance of the project, other laws and regulations are essential. All laws and regulations applicable to the project are shown in **Table 1.2** below.

Table 1.2 Relevant environmental legislation of Cote d'Ivoire

Laws and regulations	Description	Authority	Aspect
Mining Code	Law n° 2014-138 of 24 March 2014	Ministry of Mines and Industry	Mineral Resources.
Environmental Code	Law n ° 96-766 of October 3 1996	Ministry of Environment and Sustainable Development	Atmospheric pollution. Industrial waste. Energy conservation and alternative energy. Wastewater. Mineral resources
Forestry Code	Law n ° 65-425 of 20 December 1965	Ministry of Water and Forests Ministry of Wildlife and Fishery Resources	Forest conservation. Biodiversity.
Sustainable Development Act	Law n ° 2014-390 of June 20, 2014 Guidance on Sustainable Development	Ministry of Environment and Sustainable Development	Conservation of resources for future generations
Laws on protected areas.	Law n ° 66-433 of September 15, 1966, which defines the procedure for the natural integrity of national parks and	Ministry of Environment and Sustainable Development, Ministry of Water and Forests, Ministry of	Forest conservation. Biodiversity
Parks and Nature Reserves Act	Law n ° 2002-102 of 11 February 2002 on the establishment, management and funding of national parks and nature	Ministry of Environment and Sustainable Development, Ministry of Water and Forests	Creation, management and financing of national parks and nature reserves
Water Code	Law n ° 98-755 of December 23 1998	Ministry of Economic Infrastructure. Ministry of Water and Forests	Water pollution, water supply (surface water and groundwater). Wastewater.
Municipal Organisation Act	Law No. 80-1180 of 17 October 1980, attached to the municipal organization. Subsequently amended by Law No 85-578 of 29 July 1985 and Law no. 95-608 of 3	Ministry of State, Ministry of Interior and Security	Socio-economy.
Wildlife Code	Law n ° 65-255 of August 4, 1965, attached to the protection of wildlife and hunting.	Ministry of Environment and Sustainable Development Ministry of Water and Forests	Biodiversity. Conservation of forests Mineral resources

Table 1.2 (continued) Relevant environmental regulations of the Côte d'Ivoire

Hunting Code	Law n ° 66-424 of 15 September 1966 on the hunting license.	Ministry of Environment and Sustainable Development Department of Animal and Fishery Resources Ministry of Water and Forests	Biodiversity.
Labor Regulation Act	Law No. 95-15 of January 12, 1995. Amended by the law No. 97-400 of July 11, 1997. It governs the relationship between employers and employees.	Minister of Justice, Ministry of Justice Ministry of Human Rights and Public Freedoms Ministry of Employment and Social Protection	Socio-economy
Classified facilities Regulations	Decree No. 98-43 of 28 January 1998 on classified installations for environmental protection	Ministry of Environment and Sustainable Development	General provisions, authorizations and declarations Provisions common to all classified installations Financial provisions
Decree on environmental auditing	Decree No. 2005-03 of 6 January 2005 on the environmental audit	Ministry of Environment and Sustainable Development	Areas, criteria and types. Management Mode Administrative and criminal sanctions
Decree implementing the ordinance of environmental impact studies	Order No. 972 of 14 November 2007 on the application of Decree No. 96-894 of 8 November 1996 laying down rules and procedures for studies related to the environmental impact of development projects	Ministry of Environment and Sustainable Development	Managing environmental impact studies Approval of environmental consultants Financial provisions Preventive measures and sanctions
Decree determining the scale of compensation for crops destroyed	Interministerial Order No. 28 MINAGRA / MEF of 12 March 1996 laying down the schedule of compensation for crops	Ministry of Environment and Sustainable Development	Compensation rate.

Mining Code of March 24, 2014:

The relevant articles are:

Article 43- [withdrawal of mining rights].

The withdrawal comes after a notice of sixty (60) days without effect, following:

- the exploitation of children;
- the serious violation of health, safety and hygiene regulations;
- failure to fulfill obligations relating to forest conservation, environmental protection and rehabilitation of mining sites;
- breach of commitments relating to mining research and community development;
- corruption or attempted corruption in the awarding of the mining title;

Article 44

Upon expiration, resignation, removal or revocation of a mining title from the proprietor, the scope it covers is released from all duties.

All buildings, offices, wells, galleries and other permanent structures built for mining purposes automatically revert to the State under the conditions specified in the environmental management plan and the rehabilitation plan for the mine site.

Article 123

The mining rights holders are obliged to respect the rights of the people and local communities.

Article 127

The occupation of land gives right to fair compensation for the benefit of the occupier and the legitimate occupant of the land.

Article 128

Disputes relating to the amount of compensation payable or any other matters relating thereto are subject to the arbitration of administrative structures in the conditions defined by decree.

Article 129

The holder of an operating license has the right to use, for the purposes of its operations and its related industries, substances other than the minerals including the work that leads to the removal of tree species.

The occupier of the land or the legitimate occupant of the land can request permission to dispose of these substances if they are not used by the operator by payment of fair compensation, unless they come from the treatment of extracted minerals.

The right to dispose of substances other than minerals is exercised in accordance with the regulations applicable to such substances.

Article 141

Any applicant for a mining permit is required to conduct and apply for approval by the Office of Environmental and Social Impact, Study before undertaking any operational work whatsoever.

In case of pollution outside recognized standards, control expenses, subsequent verification and fines incurred are charged to the operating license holder.

Article 142

Any applicant for a business license is required to provide, along with the Study Environmental and Social Impact, a mine rehabilitation and closure plan.

Article 180

Anyone who undertakes mining without complying with safety and hygiene regulations shall be sentenced to pay a fine of 10 million to 50 million francs and a prison sentence of 1 year to 3 years or one or the other of these two penalties.

Environment Code

Law n ° 96-766 of October 3 1996: Environment Code requires in its articles:

Article 35:

When planning and implementing acts with a potentially significant impact on the environment, public authorities and individuals must comply with the following principles:

35.1 Precauationary Principle

When planning or carrying out any action, preliminary measures must be taken to avoid or reduce any risk or danger to the environment.

Anyone whose activities may have an impact on the environment should, before acting, consider the interests of others and the need to protect the environment.

If in the light of experience or scientific knowledge, action is deemed likely to cause a risk or danger to the environment, this action is taken only after prior assessment showing that it will not adversely impact the environment.

35.2 Substitution

If an action likely to have a detrimental environmental impact, which can be substituted by another action that decreases risk, the latter action is chosen even if it leads to higher costs.

35.3 Conservation of biological diversity

Any action must avoid having a significant adverse effect on biological diversity

35.4 Depletion of natural resources

To achieve sustainable development, it is necessary to avoid harming natural resources such as water, air and soil, which are an integral part of the development process and should not be considered in isolation. Irreversible effects on the land should be avoided wherever possible.

35.5 Polluter pays" Principle

Any party whose actions and / or activities cause or are likely to cause environmental damage is subject to tax and / or royalty. The polluter also assumes all rehabilitation measures.

35.6 Information and participation

Everyone has the right to be informed of the state of the environment and to participate in procedures before making decisions which may have detrimental effects to the environment.

35.7 Cooperation

Public authorities, international institutions, advocacy groups and individuals contribute to protecting the environment at all possible levels.

Article 39:

Any major project that could have an impact on the environment should be subject to a prior impact assessment. This includes programs, plans and policies that affect the environment. A decree will specify the list.

Every project is subject to control and monitoring to verify the accuracy of forecasts and take necessary corrective actions.

Article 40:

The Environmental Impact Assessment and Social Assessment must comprise:

- a description of the proposed activity;
- a description of the environment likely to be affected including specific information necessary to identify and assess the effects of the proposed activity on the environment;
- a list of products used if desired;
- a description of alternative solutions, if necessary
- an assessment of the likely or potential effects of the proposed activity and possible alternatives on the environment, including direct, indirect, cumulative, short, medium and long term impact;
- Identification and description of measures to mitigate the effects of the proposed activity and possible alternatives, the environment, and an assessment of these measures;
- an indication of gaps in knowledge and uncertainties in the development of the necessary information;
- an indication of the environmental risks of a neighboring state due to the proposed activity or alternatives;
- A brief summary of the information provided under the above headings;
- the definition of methods for regular monitoring and control of environmental indicators for the site, before (baseline), during the operation of the facility or development and, if necessary, after the end of the operation (refurbishment or redevelopment of the site);
- a financial estimate of the recommended measures to prevent, reduce or offset adverse effects on the environment and regular follow-up and monitoring of relevant environmental indicator.

Article 41

The review of environmental and social impact assessments by the Office of Environmental Impact Assessment will result in the payment of a fee to the National Environment Fund whose scope will be specified by decree.

Article 88

Any party who fails to conduct an environmental and social impact assessment prescribed by the competent authority prior to any project likely to have harmful effects on the environment, is punishable by the suspension of activity or closure of the establishment to redress the damage caused to the environment, people and property.

The falsification of environmental and social impact assessment and / or its non-compliance is punishable by the same penalties.

Decree on environmental impact studies in Côte d'Ivoire

Decree No. 96-894 of 8 November 1996 regarding the rules and procedures applicable to studies on the environmental impact of development projects requires Perseus Mining Ivory Coast to conduct an Environmental and Social Impact Assessment in accordance with the Articles and Annex:

Article 2

The following are subject to the environmental and social impact assessment:

1. the projects listed in Annex I to this decree;
2. projects located on or near environmentally sensitive areas or areas at risk set out in Annex III to this decree;
3. Where a project, because of its nature, its size or the sensitivity of the site might adversely affect the environment, the supervising Authority to investigate the technical file must request prior authorization of the Ministry of Environment.

The authorization is granted on the basis of an environmental impact assessment.

Annex I (projects subject to environmental impact assessment)

1. Mining:

   b) Extraction of minerals and quarry

Decree on environmental audit

Decree No. 2005-03 of January 6, 2005 on Environmental Audit demands the manufacturer to protect the environment during the operating phase of its facilities. Thus, the following articles provide a list of regulations and procedure.

Article 6 : Regulatory framework

The environmental audit allows the Ministry of Environment to ensure compliance, to require prevention, mitigation and repair or to take sanctions in the case of deliberate non-compliance or recidivism.

Article 17: Implementation of an Environmental Management Plan Audit

The Plan of Environmental Management-Audit is designed by ANDE to assist companies in consideration of the environment in their activities. The establishment of the audit is mandatory for companies that do not have an Environmental Management System. The National Environment Agency is responsible for the implementation of the audit and the related costs are the company's expense. All environmental management tools implemented in a company must be approved by the National Agency for the Environment.

Article 19: Record keeping

Any party who operates a facility or structure constituting a threat to the environment is restricted by the systematic record keeping which will help to provide evidence of sound management of its activities.

Article 20: Records

The records referred to in Article 19 include:

- release of industrial wastewater;
- atmospheric emissions;
- management of solid, liquid and hazardous waste;
- management of chemicals.
-

This list is not exhaustive and records can be adapted by the company concerned by the activities of the latter.

International requirements

The study undertaken should meet the requirements of the Equator Principles (EPFI). The Equator Principles refer to the operational standards required by the IFC (World Bank Group, 1995). It is essential that mining completely complies with the legislation of the host country, including the acts, laws, regulations and license conditions.

The next chapter of Ivorian legislation refers to the Equator Principles and IFC guidelines.

Equator Principles

In addition to the regulatory texts of the Ivory Coast, the audit will comply with the Equator Principles. The Equator Principles are based on the policies and the International Finance Corporation guidelines (IFC), which is the branch of private sector development of the World Bank Group.

The major financial institutions that adopt the Equator Principles are known as EPFI. The Equator Principles are a voluntary adoption of social and environmental policies, procedures, standards and loan limits for EPFI borrowers who succeed in these principles

Standards of the International Finance Corporation

The IFC Performance Standards on Environmental and Social Sustainability address the aspects and social and environmental impacts associated with the development of the project. Performance standards require that the impacts and social and environmental risks of a project are identified and assessed at an early stage of project development and continue to be managed throughout the project life.

Environmental, medical and safety guidelines provide general and specific advice for good practice and limits related to the health and safety of the community, noise, emissions and disposal of waste. IFC classifies the proposed project into one of four categories, depending on the type, location, sensitivity and scale of the project and the nature and magnitude of its potential environmental impacts (IFC, 2006).Those are :

Category A: A proposed project is classified as category A if its serious adverse environmental potential impacts are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the site or mining facilities.

Category B: A proposed project is classified as Category B if it has potential adverse impacts on human populations or important and sensitive areas - including wetlands, forests, grasslands and other natural habitats - less adverse than those of Category A projects . These impacts are site-specific; few of them are irreversible; and in most cases mitigation measures can be designed more easily than the projects in Category A. The Pollution Prevention and Abatement Handbook (Handbook on the reduction and prevention of pollution) (PPAH; World Bank 1998) considers the expansion of existing operations as a project in category B.

Category C: A proposed project is classified as category C if its environmental impacts are minimal or nonexistent.

Category FI*:* A proposed project is classified as Category FI if it involves investment of IFC funds through a financial intermediary, in subprojects that may have adverse environmental impacts.

There are eight IFC Performance Standards.

The most important is the performance standard 1 relating to the policies of the International Finance Corporation on social and environmental sustainability. This standard requires the investigator of the project to not only assess the social and environmental impacts of the project but also to ensure the ongoing management of social and environmental performance throughout the life cycle of the project.

Procedures for long-term monitoring and records of the effectiveness of risk management measures are also standard requirements.

The following elements should be incorporated into the management system:

- social and environmental assessment;
- management program;
- organizational capacity;
- training;
- community involvement;
- control;
- reports (IFC, 2006).

Project Classification

The Equator Principles (Equator Principles, 2006) require that a project be classified in accordance with the IFC criteria. As described in the previous section, there are four different categories of projects.

The Sissingue gold project has been classified as Category A, justifying the completion of this environmental impact assessment.

Regional and International Conventions

Below are the regional and international conventions ratified by Côte d'Ivoire. Perseus Mining Ivory Coast will incorporate the requirements of these Conventions in its environmental policy. These conventions are listed in Table 1.3 below.

Table 1.3 International conventions and agreements related to the project

Convention – Place and date of passage	**Date of ratificatio**
Stockholm Convention on Persistent Organic Pollutants	2003
RAMSAR Convention on Wetlands of International Importance to ensure better protection of habitat and nesting sites of some migratory species	1996
Bamako Convention on the Prohibition of hazardous waste in Africa	1994
Convention - United Nations Framework on Climate Change	1994
Convention on Biological Diversity, Rio de Janeiro, 1992	1994
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1994
Convention for the protection of the ozone layer, Vienna 1988 Montreal Protocol, 1987, amendment London 990	1993
Water Charter of the Niger Basin	2008

Basic principle: Human Rights and the Environment

At the International Level

Principle 1 of the Stockholm Declaration following the UN Conference on Environment and Development in 1972 proclaimed that "Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being. He has a solemn duty to protect and improve the environment for present and future generations. "

The Declaration of the Rio Conference in 1992 follows in a similar vein. Principle 1 states that "human beings (...) are entitled to a healthy and productive life in harmony with nature." Regionally, the human right to the environment was also affirmed. The African Charter on Human and Peoples' Rights adopted in Nairobi 28 June 1981 recognizes in Article 24 that "all peoples have the right to a satisfactory environment, comprehensive and conducive to their development."

1.4 AT THE NATIONAL LEVEL

The Ivorian Constitution of 1 August 2000 declares in Article 19, the human right to the environment. This reference is a significant step because this is the first time that environmental protection was a high constitutional standard.

1.3.2 Institutional Framework

The Côte d'Ivoire established environmental regulatory structures in the early 1970s, specifically on June 8, 1971. There were many changes and different names, but there has been a growing interest in the protection of the environment.

Therefore, the Ministry for the Environment was created and with it, several administrative structures and essential legal counsels inlcuding the Directorate General Environment (DGE), the Ivorian Anti-Pollution Centre (CIAPOL), the Ivorian Office Parks and Reserves (OIPR), the National Agency for the Environment (ANDE), the Department of Forestry, the Department of Water Resources (DRE) and the Natural Resources Department.

To extend its actions on the territory, the ministry responsible for the environment has brought services to the population by creating Regional Directorates.

For this project, the Ministries involved are:

- the Ministry of Environment and Sustainable Development;
- the Ministry of Mines and Industry with the General Direction of Mines and Geology and Mining Interministerial Commission (COMINE) responsible for approving the documents submitted for the granting of the operating license;
- the Ministry of Agriculture with the General Directorate of Rural Development;
- the Ministry of Construction and Urban Planning with the Town Planning Department, the Department of Construction and Housing;
- Ministry of Economic Infrastructure with the General Directorate of Water Supply, the National Office of Drinking Water (ONEP), the Road Management Agency (AGEROUTE);
- the Ministry of Water and Forests with the Water Resources Department;
- the Ministry of State, Ministry of Interior and Security;
- the Ministry of Health and Public Hygiene;
- the Ministry of Transport;
- the Ministry of Wildlife and Fisheries.

2.0 PROJECT DESCRIPTION

2.1 INTRODUCTION

In October 2014, Perseus Mining Limited (Perseus) engaged Lycopodium Minerals Pty Ltd. (Lycopodium) to coordinate a Definitive Feasibility Study (DFS) for its Sissingue gold project (the Project), located north of the Ivory Coast.

The study is based on previously published reports and includes new contributions from resources within Perseus and other focus groups, as shown on **Table 2.1** Contributors to the study.

Table 2.1 Contributors to the studySection

	Contributors and reports
Section 1 Summary document	Everyone
Section 2 Location, owner and license	Lycopodium / Perseus
Section 3 Geology and resources	Snowdon Mining Industry Consultants
Section 4 Mining and Quarry	Runge Pincock Minarco (RPM)
Section 5 Metallurgy	Perseus
Section 6 Treatment faciliities	Lycopodium
Section 7 Infrastructure	Lycopodium
Section 8 Tailings storage and water balance of the site	Worley Parsons
Section 9 Environmental and social impact	CECAF International (ESIA, December 2011)
Section 10 Operational Services	Lycopodium
Section 11 Operation	Lycopodium
Section 12 Estimated operation costs	Lycopodium / RPM
Section 13 Capital cost estimate	Lycopodium / RPM
Section 14 Financial analysis	Perseus
Section 15 Risks and opportunities	Compilé par Lycopodium

Following the laws and regulations in Côte d'Ivoire, Perseus Mining Ivory Coast has asked the Office of CECAF International Studies, approved by the Ministry of the Environment and Sustainable Development of the Ivory Coast, to achieve the addendum of the 2011 ESIA.

2.2 LOCATION AND PLAN

The Sissingue Gold Project, formerly known as the Tengrela Gold Project, is located in northern Côte d'Ivoire, near the border with Mali and about 700 km north of the business capital, Abidjan. The nearest town is Tengrela, about 15 km west of the limits of the mine. Korhogo, the main regional center, is 150 km south-east of the mine.

The Project area is 1,141,666N of the contact center and 804,166E of the national topographic network.

Table 2.2 General area of the Sissingue Gold Project in Côte d'Ivoire

Occidental Gold SARL ("OGIC"), then a wholly owned subsidiary of Afminex Limited ("Afminex") and the Mining Society of Côte d'Ivoire SARL ("SOMICI") have signed a joint business agreement on September 29 1997 ("1997 Agreement") regarding the exploration and development of the Project, OGIC holds 90% interest in the Project and SOMICI 10%.

An agreement dated 20 May 2009 was signed between OGIC and SOMICI under which an option was granted to OGIC for buying a 5% stake in the project from SOMICI. In December 2010, OGIC exercised this option, bringing its stake to 95% and reducing that of SOMICI 5%.

Perseus bought its participation in the Project in agreements dated March 2004, under which Afminex sold all its shares of Western Gold Pty Ltd ("OGPL") (which holds all the shares of OGIC) and loans associated with Perseus for a consideration of shares in Perseus and royalties.

The Tengrela East exploration permit has been renewed for the last time on 21 April 2009 and expired on 19 November 2011. Replacing the Tengrela East exploration permit, OGIC was awarded in August 2012, was the permit 'PE operation 39 (the "operating Permit") for the development of the Sissingue gold deposit. The operating license was then transferred to another company Ivorian subsidiary, Perseus Mining Côte d'Ivoire SA ("PMCI") in July 2013.

As a result of the award of the operating license for the Project, the Government of Côte d'Ivoire has a free statutory 10% interest in the Project and the participation of OGIC was reduced to 85%. This is reflected as follows in the participation level of ITAPs:

Perseus (via OGPL): 85%

The State of Côte d'Ivoire (held by SOMICI and to be transferred to the State): 10% SOMICI: 5%

OGPL is a company registered in Australia, and is a wholly owned subsidiary of Perseus Mining Limited. As part of the exploration license, ITAPs should have started production-related license no later than 8 August 2014. By order dated 17 March 2014, the Ivorian government granted two additional years, beginning on the anniversary of the original order.

Sissingue is currently the main centre of interest for development of the Project, but several other mineralized zones were identified in the permit of operation. **Table 2.2 General area of the Sissingue Gold Project in Côte d'Ivoire** shows the location of all known mineralized zones, mineral resources, mineral reserves and mine works, from the external boundaries of the property. All areas of mineralization and ore resources were accurately located and there is no risk that some of the ore resources are outside the boundaries of the concession.

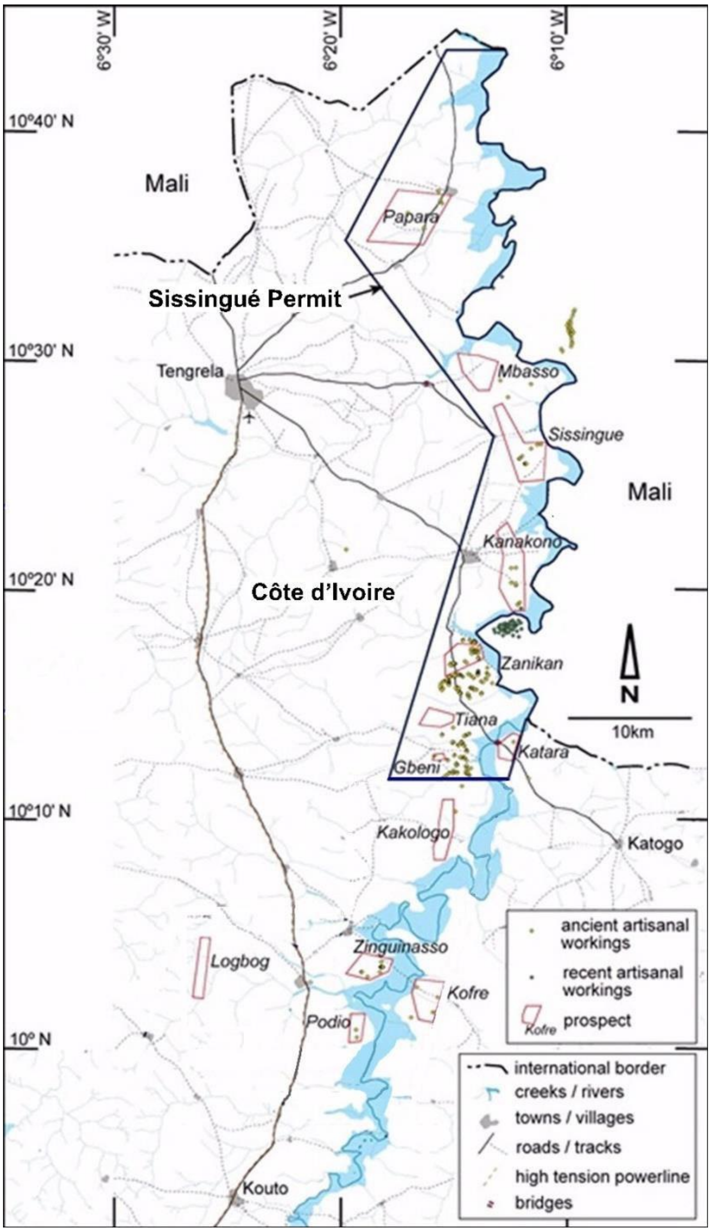


Table 2.3 Location of known mineralized areas

2.3 GEOLOGY AND RESOURCES

2.3.1 Regional and local geology and mineralization

The Sissingue deposit is located within the Tengrela project area, located in the greenstone belt of Syama-Boundiali. The geology of the area has similarities with the better known Ashanti belt in neighboring Ghana, where volcaniclastic Birimian dominate the volcanic rocks with the development of inland basins on a belt filled with epiclastic tarkwaiens. Around the Bagoé River near Tengrela, the field consists of undifferentiated granitoids of flysch sediments of intermediate volcanic rocks and small occurrences of mafic sediments and sandstone.

The mining area covers a Birimian greenstone belt strongly distorted by granite. Interpretation of aeromagnetic and radiometric data indicates the inclusion of a large chain of northbound volcaniclastic Birimian penetrated by a large felsic mass (Kanakono Pluto) and several small felsic intrusions rich in uranium.

The Sissingue deposit consists of a gold deposit in soil, 4 km long and 1.5 km wide in the greenstone belt of Syama-Boundiali. The rocks found in outcrops and boreholes mainly include Isoclinal sediment folds (sandstone, mudstone and conglomerate side) of the Birimian supergroup, interpreted as units of turbidite flows towards the north northeast, sinking deep west. These sediments are crossed by a swarm of narrow porphyritic ditches (with a thickness ranging from less than a meter to several meters) advancing obliquely towards the sedimentary package northwest, with deep sub-vertical slopes to moderate south-east. Some minor gaps appear to have exploited the weak zones parallel to sedimentary layers.

Gold mineralization was found in three distinct forms presented below:

Disseminated mineralization with a fracture in the sericite-carbonate alteration closely associated in the felsic intrusive, silicification and mineralization of pyrite and arsenopyrite. The average gold grade of this type of mineralization is typically relatively high (2 to 5 grams of gold per tonne).

A less significant gold mineralization (often less than 2 g of gold per tonne) is found among sediment immediately adjacent to intrusive bodies in their respective halo alteration. The gold content is perceived as being closely related to the intensity of the alteration and therefore with a fundamental porosity rocks. The sandstone and conglomerate generally mineralize better than the fine grain mudstone and siltstone.

A high grade mineralization (with levels in excess of 1000 g of gold per tonne) is associated with quartz veins that are found in the upper part of the body and intrusive in the altered portion and friable sediments directly above. Gold visible to the naked eye is common.

It appears that the supergene alteration has an effect on the distribution of gold. Maps and sample histograms of different eroded areas suggest that the amount of gold has been reduced in altered oxidized ground. Water infiltration caused the enrichment of gold in the transition zone and the growth of nuggets where existing nuggets were released from the host rock during the weathering process.

2.3.2 Survey data

The input data used to estimate Sissingue resource contained 131,744 samples over 199,269 m, including 36 113 m located within the mineralized domains.

Data from the Sissingue ore resource area are illustrated in the overall plan in **Table 2.4**.

2.4 GEOLOGY AND MINERALIZATION AREAS

Mineralization has been sectored by its lithology for modeling (granite, porphyritic ditches and sediment). Mineralized sediments in the trenches of the alteration halo were included in the field ditches to retain a minimum width of wireframes and to maintain continuity along the vein. When the geological contacts have not clearly controlled the distribution of mineralization, a cut-off grade of 0.3 grams of gold per tonne was used to build the limits of the ore resource and to provide general geometry of the mineralized zones. A minimum width of 4 m was used for wired figures and samples below the nominal cut-off grade of 0.3 grams of gold per tonne were included where the structure would otherwise be less than 4 m wide. The analysis of the overall distribution of contents shows that natural modification of the contents occurs at about 0.3 grams of gold per tonne.

An overall plan of the major modeling domains is shown in **Table 2.4**

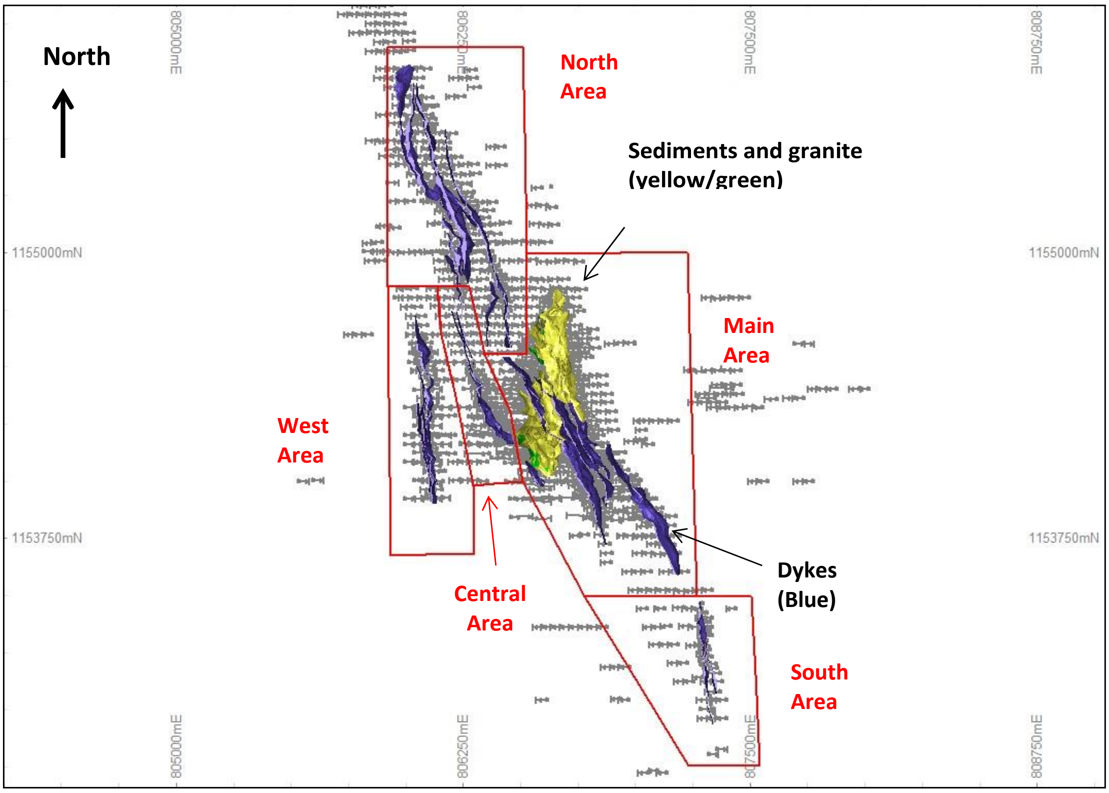


Table 2.4 Plan of the mineralized areas from surveys and Project areas

Perseus created a topographic surface and erosion profile and provided the models for Snowden. **Table 2.5** shows a cross section of the topography and four eroded surfaces. The analysis of the oxidized areas, transitional and freshly eroded in granites, sediments and pits, indicates that the levels of distributions have similar shapes, with generally higher levels in the transitional area.

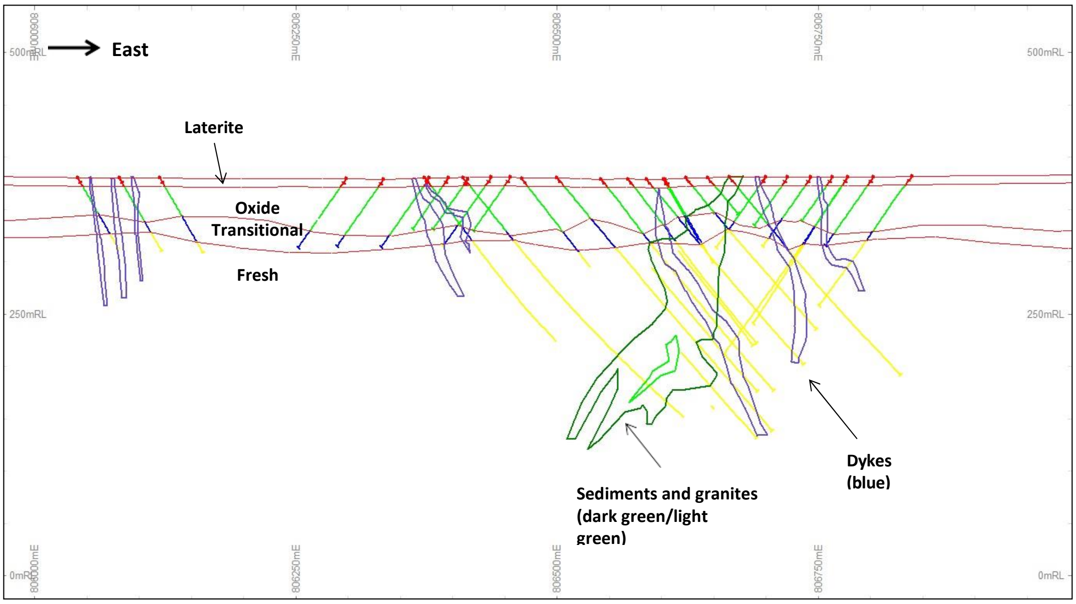


Table 2.5 Cross section showing topography and eroded surfaces

2.5 CLASSIFICATION AND REPORTING OF MINERAL RESOURCES

Snowden has reviewed the classification applied in the previous estimate (Widenbar, 2013) and concluded that it was appropriate with regard to the level of confidence in the estimates of tonnes and grades. Recent information about mining recovery factors however led to an optimization test to determine the potential for commercial extraction, particularly for peripheral and lower grade mineralization.

Table 2.6 summarizes the resources by category and sector, reported as having a cut-off grade of 0.6 g of gold per tonne. The classification categories Inferred, Indicated and Measured are in accordance with the JORC Code (2012). They are equivalent to the CIM classes of the same name (CIM, 2010).

Table 2.6 October 2014, Sissingue Mineral Resource has announced a cut-off gradeof 0.6 grams of gold per tonne

Category	Zone	Tonnage (kt)	Content (g gold / t)	Gold content (oz)
Measurment	Oxide	1 000	1.8	59 000
	Transitional	650	2.3	49 000
	Fresh	3 200	2.5	260 000
Total Measured		**4 800**	**2.4**	**370 000**
Indicated	Oxide	3 100	1.3	130 000
	Transitional	800	1.5	38 000
	Fresh	7 100	1.5	350 000
Total Specified		**11**	**1.4**	**510 000**
Measured + Indicated	Oxide	4 100	1.4	190 000
	Transitional	1 400	1.9	87 000
	Fresh	10	1.8	600 000
Total Measured + Indicated		**16**	**1.7**	**880 000**
Inferred	Oxide	310	1.2	12 000
	Transitional	54	1.2	2 100
	Fresh	760	2.0	49 000
Total Inferred		**1 100**	**1.7**	**60 000**

Notes: Mineral resources include mineral reserves. The mineral resources are reported in two significant figures. Rounded numbers may cause minor differences on the table. The oxidized areas include small parts of laterite (571 kt total).

A comparison with the previous report of Mineral Resources (Widenbar, 2013) shows that the updated estimate is more selective, resulting in higher levels in the central portion measured from the estimate. This gives an additional 60 koz in the Measured category.

The increased selectivity of the updated estimate is a consequence of the use of MIK estimate to witness the mixed distribution, extremely biased in the areas of granite and sediments.

There is a decrease of Indicated and Inferred resources as a result of the implementation of Project Feasibility limits to define potentially mineable areas.

2.6 MINING

A mining study was conducted by RungePincockMinaro ("RPM") in close collaboration with the staff of Perseus.

The economic feasibility limits were determined using the feasibility limits of optimization software Whittle 4X ("Whittle 4X Optimize"). Whittle 4X optimization was based on the Surpac block model formats prepared by Snowden Mining Industry Consultants, geotechnical parameters estimated by

Coffey Mining and Metallurgical extraction, operating costs and metal prices provided by Perseus. The reference scenario for the metal price was US $ 1200 / troy ounce.

2.6.1 Commercial quantities

The mining method provided for the operation is a conventional excavation of open pit with waste outside of the well. The well will be accessible via a transport route of 20 m wide, angled at 10% and having two channels. At the bottom of the pit, it will access the last levels by single lane ramps.

Based on the design parameters of the pit established and its optimization, three drawings of detailed phases were prepared. These three mining phases appear on the section plane of **Table 2.7**

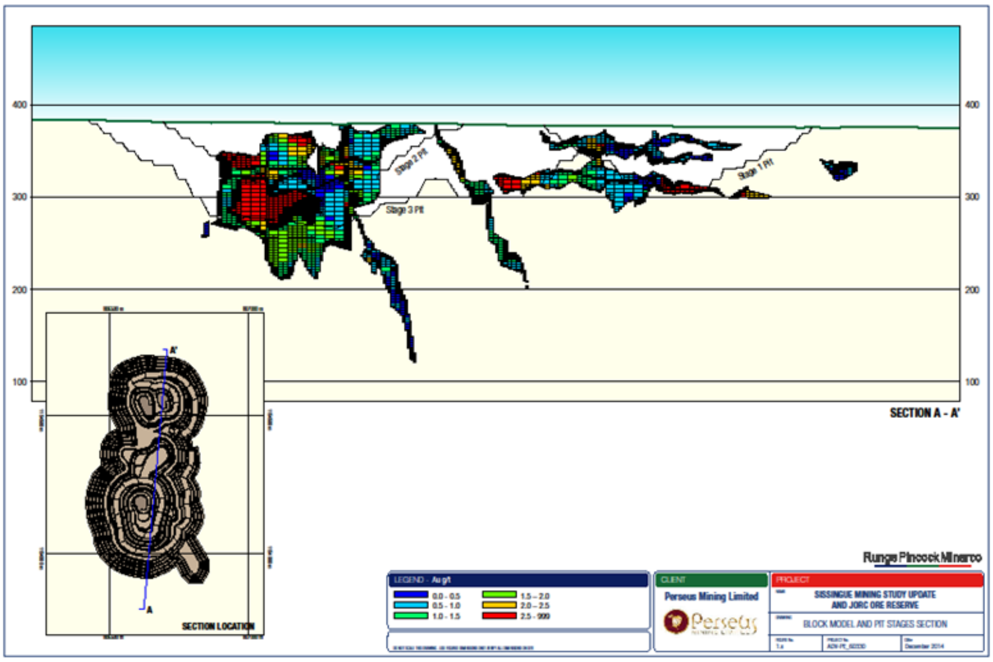


Table 2.7 Cross-section of well phases

Ramp exit points on each design were placed in the East to provide the shortest access routes to the area of fill and discharge of waste rock.

The resulting commercial quantities of ore and waste for the three phases of the projects are presented in **Table 2.8**.

Table 2.8 Commercial quantities

Phase	Type of erosion	Mt of waste	Mt of ore	Stripping ratio t/t	Ore grade content g/t
1	Oxide	3.3	0.5	6.2	2.1
	Transitional	0.4	0.2	1.8	2.7
	Fresh	0.3	0.4	0.6	2.1
Phase 1 Total		**3.9**	**1.2**	**3.3**	**2.2**
2	Oxide	3.2	0.8	4.2	1.4
Phase	**Type of erosion**	**Mt of waste**	**Mt of ore**	**Stripping ratio t/t**	**Ore grade content g/t**
	Transitionn	0.3	0.3	1.1	1.7
	Frais	0.1	0.5	0.3	3.6
Phase 2 Total		**3.6**	**1.5**	**2.4**	**2.1**
3	Oxydé	6.1	0.7	8.3	1.4
	Transitionn	1.6	0.3	5.2	2.4
	Frais	2.5	1.8	1.4	3.1
Phase 3 Total		**10.**	**2.8**	**3.6**	**2.6**
Total of all Phases		**17.**	**5.5**	**3.2**	**2.4**

2.6.2 Operating costs

RPM has prepared a specific model of operating costs with its financial modeling software Xeras for a scenario of the mining contractor.

Mining costs were estimated from a quote by DTP Terrassement ("DTP") (the experienced local division of French mining contractor Bouygues Construction) and RPM on the part of the client including management based on the site, supervision and technical assistance, with the contribution of Perseus.

The costs of the duration of mining, following the adjustment of the DTP quote based on the final operating program, after adding fuel costs, appear in **Table 2.9** below.

Table 2.9 Adjusted estimate of the mining contractor

RPM Estimation						
Area	**Description of the area**	**Unit**	**Driver**	**Rate**	**Unit**	**Total in millions of $**
1	Creation of the site	n°	1	3 609	1000 $ US	3.6
2	Fixed monthly sum	Month	65	512	1000 $ US	33.3
3	Preparation of the area	km²	796	0.88	$ US	0.7
4	Drilling	kdrm	172	22.4	$ US	3.8
5	Explosives	K trous	21,8	173	$ US	3.8
6	Digging, loading, transport and	kbcm	10	3.63	$ US	39.5
7	Redesign	kt	5 525	0.60	$ US	3.3
8	Reclamation	Month	65	32.1 9	1000 $ US	2.1
9	Grade control	kt	5 525	0.24	$ US	1.3
Total						**91.4**

During the life of the operation, this equates to an average cost of $ 16.55 per tonne of ore or $ 8.42 / bcm or $ 3.95 / tonne of rock. The chart below highlights the main items of expenditure for mining. The activities of 'fixed monthly sum and digging, loading, transport and dumping account for 80% of total cost.

2.6.3 Kinds of ore

A total of 5.5 Mt of ore reserves at 2.4 grams of gold was estimated on 1 February 2015 (**Table 2.10**).

Table 2.10 Februrary 2015 Open pit ore reserves

Classification	**Dry tonne Mt**	**Gold content g/t**	**Gold koz**
Certain	3.4	2.8	312
Probable	2.1	1.7	115
Certain +	**5.5**	**2.4**	**429**

Estimates have been rounded to two significant figures to reflect accuracy.
The ore reserve previously published on 22 December 2010 showed 9.7 Mt. The changes since the previous survey in December 2010 concern the recovery rates, costs and the annual capacity of the plant.

2.6.4 Production schedule

A detailed production schedule for the life of the mine was established for the Project. The full life of the mine has been scheduled in monthly periods. Mining production begins during the sixth month and varies from 60 to 100% of capacity over a period of three months.

Table 2.11 shows the total ore output from the pit, per phase, while **Table 2.12** shows the monthly tonnage of ore processed by facilities, by type of ore.

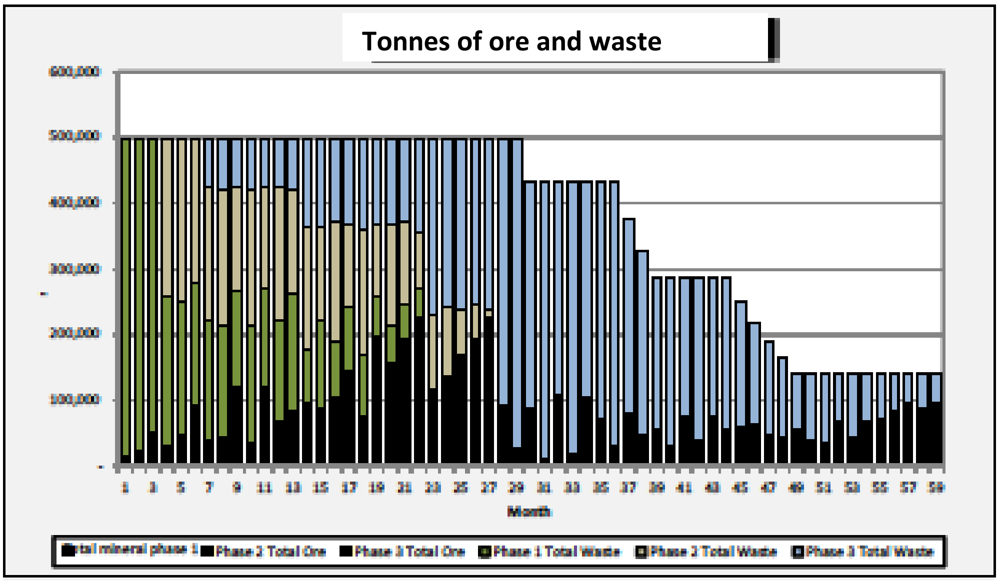


Table 2.11 Total monthly ore output by phase

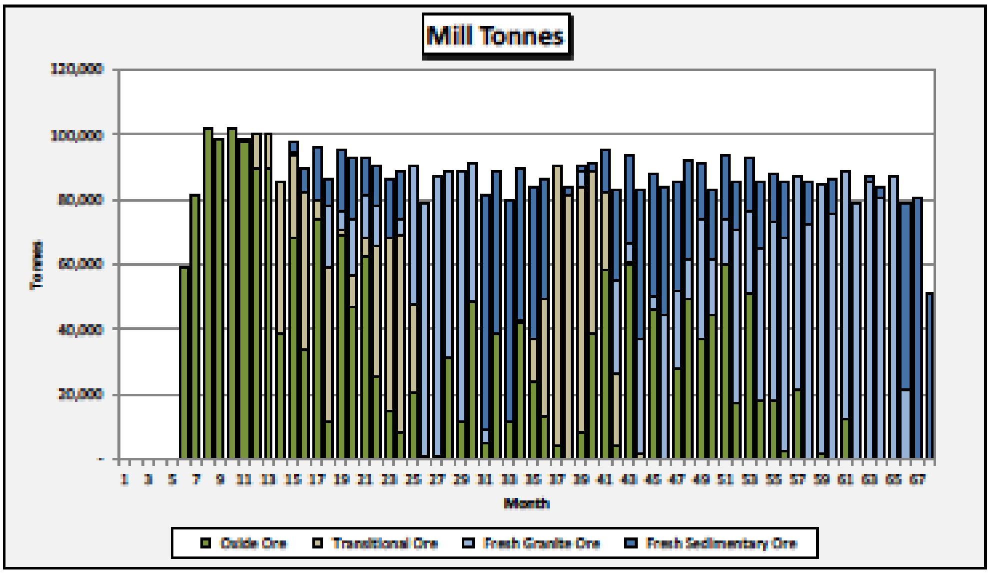


Table 2.12 Monthly tonnage of ore processed by ore type

Table 2.13 shows gold recovered each month.

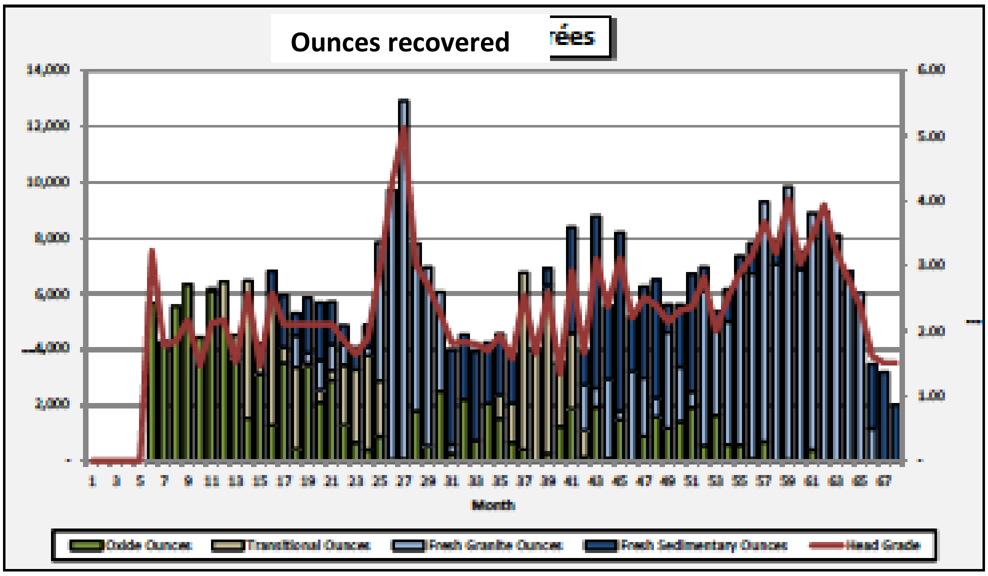


Table 2.13 Gold mined per month

2.7 METALLURGY AND WASTE TREATMENT

2.7.1 Metallurgy

A series of three metallurgical testing programs was carried out between 2010 and 2012 to support the feasibility study for the Sissingue Gold Project.

The findings of the test programs on Sissingue samples are:

Sissingue Samples generally did not require processing or absorption by carbon components, and they react to the extraction of gold by conventional cyanidation. Some of the samples tested showed a refractory nature, it should be noted that only two of these are within the expected extraction zone.

Samples from oxidized sectors were generally accompanied by high recovery rates (90 to 98%) to a P80 crush size of 106 .mu.m. The leaching kinetics is variable, approximately 40% of the specimens were separated completely in 24 hours while the rest were separated slowly in 48 hours.

Granite sulfide samples generally have a high recovery rate (87-94%) and separated slowly, a 48-hour leaching period is required.

The sulfur samples found in porphyry respond in the same manner as the granite samples.

Samples of sulfur present in the sediments had varying recovery rates ranging from 39.9 to 95.6%. A slow leaching time component is present, and a 48 hours leaching time is necessary.

The oxide and sulfide samples have different physical characteristics and spray. The oxidized material is soft and non-abrasive while sulfur is abrasive and hard. The oxidised material will be processed by a grinding circuit in two stages, a third milling step is added for the treatment of sulfur.

Gravity tests showed a variable recovery (0.7% to 87.4%) of gold by centrifugal concentration of gravity and intense cyanidation of gravity concentrate. A gravity circuit was included in the treatment for visible gold is present in drill core.

A pre-oxidation is considered beneficial to the kinetics of leaching and the overall recovery, particularly for sulfur samples.

2.7.2 Processing plant

The design proposed for the Sissingue Gold Project processing plant is based on a robust processing circuit designed for optimal recovery and minimal operating costs. This circuit is constructed from holdings that have proven in industrial operations.

A simplified flow diagram depicting the operations of the unit incorporated in the selected processing circuit appears in the processing flow 110-PRPFD-0001.

The plant will treat a range Sissingue ore (oxide ores, transitional and primary porphyry, granite and sediments) with different mineral characteristics, gold grades and metallurgical processing requirements. Primary ores are considerably more competent than the oxide ores and require a longer time to optimize leach gold recovery.

The facilities plan is shown in **Table 2.14**

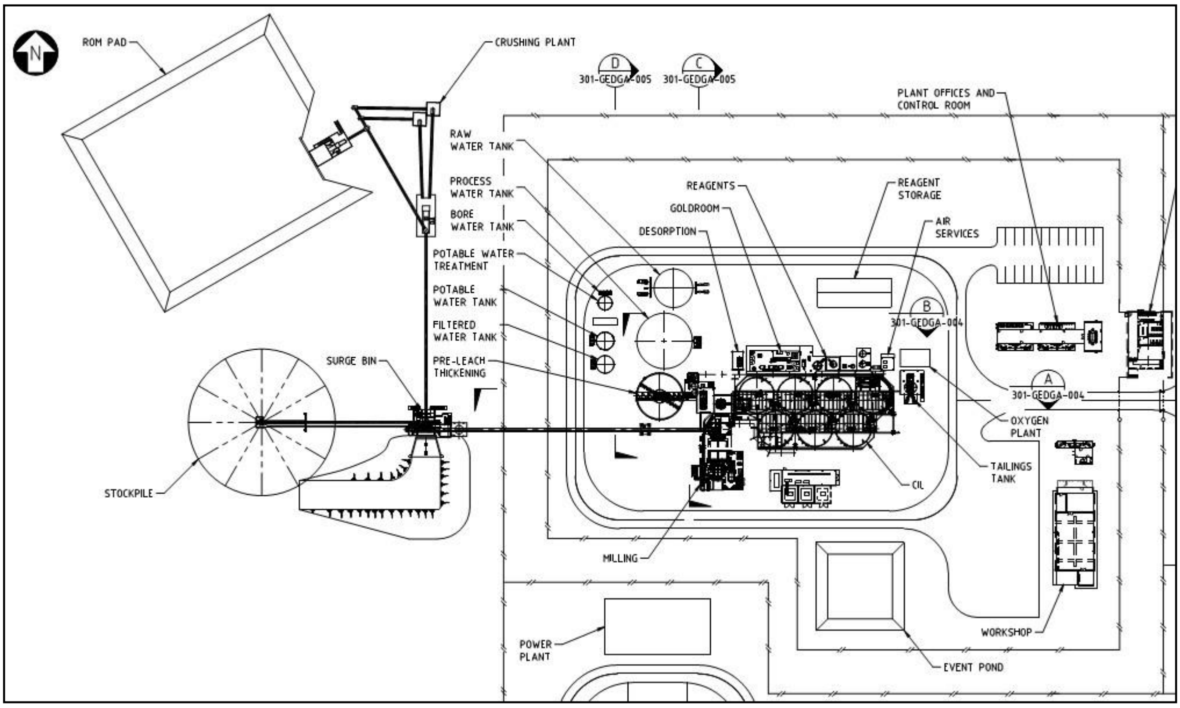


Table 2.14 Arrangement of the processing plant

The minerals will be extracted from the predominantly oxidized/transitional ore and treated in two phases. The oxidized ore will be processed at a rate of up to 1.2 Mt / year using a grinding circuit with two stages and a SAG mill (SAG). The primary ore will be processed at a rate of up to 1 Mt / year using a grinding circuit and ball milling in three stages, the SAG has been reconfigured to operate as ball mill.

The key design criteria of treatment used as the basis for the design of the process plant and equipment selection appear in **Table 2.15**.

Table 2.15 Summary of key design for processing

		Oxide	Primary mixture	Source
Capacity of the grinding circuit	t/year	1 200 000	1 000 000	Perseus
Production of the facility - Design	t/year	1 200 000	800 000	Perseus
Production of the facility – Max. nominal	t/year		1 000 000	Perseus
Description of gold supply	gold /t	2.50	3.75	Perseus
Gold recovery design	%	92	90	Perseus
Crushing facility	%	70.0		Lycopodium
Facility availability	%	91.3		Lycopodiu
Spray circuit		2nd grinding & SAG	3rd grinding & ball mill	Perseus / OMC
Crush size, P_{80}	mm	32	9.5	OMC
Grain size, P_{80}	µm	106	106	Perseus
Power of grinding gears	kW	620	1 750	Perseus
Length of leaching/CIL	h	31	48	Perseus
Leaching pulp density	% w/w	45	52	Test
Number of pre-oxidation tanks		0	1	Perseus
Total leaching tank		1	0	Perseus
Total absorption reservoirs		6	6	Perseus
Cyanide consumption[5]	kg/t	0.51	0.59	Perseus
Quick lime consumption[6]	kg/t	0.76	0.32	Perseus
Type of elution system		Zadra		Perseus
Elution circuit size	t	4		Lycopodiu
Elution frequency	bands / week	7	4	Lycopodium

It is initially planned to treat oxide ore at 1.8 Mt / year and then 0.8 Mt / year with a production target of 70,000 oz / year. The primary ore will be treated at faster rates than the 0.8 Mt / year chosen at the beginning of the Project. Leaching density power will be increased to compensate for the higher production rate and cyanide will be added to the first leaching tank as needed. Increased production is feasible because the ball mill has been designed to receive the type of harder ore, providing additional capacity for mixtures of softer minerals in the mine plan.

The overall design for plant control is a low level of automation and remote control equipment. Instruments will be provided in the facility to measure and monitor the essential parameters of treatment. The main control room, which is adjacent to the factory offices, will house two cross-platform terminals. These will act as control systems of servers and data acquisition as well as configuration / operation stations. The control room is intended to provide a central area from which the facilities are operated and monitored, and where regulatory control loops can be observed and controlled. All important parameters of processing and maintenance will be available for trends with alarms in the process control system.

2.8 INFRASTRUCTURE

2.8.1 Site layout

The overall site development plan appears in **Table 2.16** and Drawing 301-GEDGA-0001. The drawing shows the main features of the project and its infrastructure, including the process plant, tailings storage facilities, the camp, roads, airstrip, the area of mining services, the open pit mine and waste rock dump.

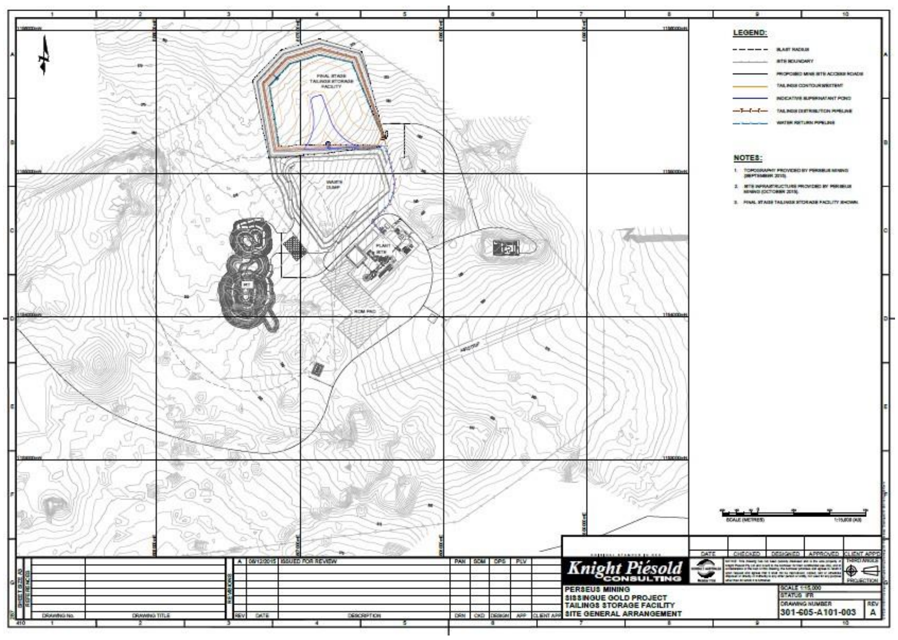


Table 2.16 Site layout

The processing plant and the tailings are located on the east side of the open pit of Sissingue, just outside the 500 m security blasting perimeter. The mining camp and airstrip are located south / southwest of treatment facilities.

The main access road approaches the site from the west and offers easy access for staff and transportation of materials.

The whole site is fenced to clearly delineate the mining area, preventing access by animals and unauthorized persons. Road access to the fenced area will be guarded by a checkpoint. Site security is based on concentric lines of fences. Security fences surround the mining camp and the site's general infrastructure. A monitored high security gate surrounds the processing facilities.

The existing road, about 23 km long and between Tengrela and Sissingue, will be transformed into six meters of wide gravel, passable in all weather, with a system for the free flow of water, to provide access for the delivery of equipment, materials and services on the site.

2.8.2 Airstrip description

A 1 400 m long by 80 m wide runway, made of gravel and usable in all weather conditions will be provided for charter flights, to take staff between the site and Abidjan, and for the safe transport of gold bars to Abidjan and the refinery. The airstrip can also be used for emergency medical evacuation.

Ditches will be constructed on either side of the airstrip for drainage of rainwater. Around the airstrip surface, a buffer zone consisting of a grassy strip will be built to retain the suspended solids from storm water runoff on airstrip.

A view of the airstrip site is presented in Photo 1 and **Table 2.17** following:

Photo 1: View of the runway site

Table 2.17 Landing runway

The operation of the airstrip adheres to a number of national requirements including runway safety and training plans.

The maximum and minimum mean monthly wind speeds are respectively 3.1 m / s (11.16 km / h) and 2.1m / s (7.56 km / h). Their dominant direction is northeast (January and February), the east (in December) and the southwest (the other months of the year).

The airstrip is in the direction of the Southeast, so as to minimize the impacts on noise and air emissions on the population.

2.8.2.1 National runway safety program

Guidance material is given to any operator for runway safety for all Ivorian air space open to public air traffic. The national runway safety program aims to:

- eliminate runway safety risks;
- minimize risks that persist;
- reduce active failures and mitigate the seriousness of their consequences, in order to improve runway safety by integrating safety management systems (SMS) of all organizations involved therein. This integration is achieved through the identification of hazards and risk management related to runway safety collaborative and multidisciplinary manner, and the communication of safety issues at operational staff.

Thus, the program specifically addresses the issue of risk prevention in the context of the safety of aircraft operation, air traffic management, vehicle movements on the maneuvering area and the management of the air space.

2.8.2.2 Runway safety

Creation of the board

A National Safety Committee allows the exchange of information promoting good runway safety practices at a national level in order to improve runway safety and reducing the risk of raids.

Committee Composition

The Safety Committee is chaired by the Director General of the National Authority of Civil Aviation and consists of representatives from the following:

- air strip operators;
- Air traffic service providers;
- firefighters;
- air operators;
- the ground handling companies;
- air forces;
- the police and airport police;
- pilot associations, air traffic monitors and aviation safety controllers;
- any other party involved in the surface operations.

The Committee shall meet at least three times a year. Each committee member's role is to look for problems related to runway safety, the recommendations and comments of his entity and present them to the Committee.

Committee Roles

The Committee is responsible for:

- accompanying and supporting the Ivorian airports in creating runway security teams;
- studying the hazards identified at the national level related to runway safety;
- promoting good practices, sharing information and improving awareness of the industry to runway safety through training;
- acting as a focal point of coordination in the area of runway safety for industry;
- identifying and examining the technologies available to reduce risks of runway raids;
- reviewing current procedures operating from air traffic control (ATC) and aircraft operators and if necessary make recommendations on these procedures to reduce the risk of raids;
- developing recommendations for guidance to the industry on operational issues in relation to the aerodrome, ATC and planes to reduce the risk of raids;
- promoting the notification process of runway raid incidents;
- Ensuring thorough analysis of data to identify and examine specific areas of concern.

2.8.2.3 Training

A local campaign regarding raid prevention awareness must be launched at each air space for controllers, pilots, drivers and other personnel involved in surface operations.

This campaign will be updated from time to time to maintain their interest and to benefit the holding. The pilots, controllers and drivers will receive training and a common familiarization for their understanding of the roles and challenges of working with staff. If possible, all interested parties should visit the area to become familiar with the guide signs, markings and airfield plan.

2.8.2.4 Runway safety action plan

The security team for each runway must develop a plan containing measures to mitigate the shortcomings of runway safety. These measures should be specific to the area and related concern, question or problem regarding runway safety.

They could include a recommendation to alter the physical characteristics or the facilities, the air traffic control procedures, the conditions for access, driver and pilot awareness and the production of maps of hot spots.

This action plan should clearly define responsibilities for the tasks associated with each action. Each step should be taken by the designated person or organization responsible for carrying out the various relevant tasks. More than one person or organization may be affected by the measure to be taken, but only one person or organization should take the lead and be responsible for the completion of all tasks associated with it. Work on a given task should be completed within a reasonable time.

2.8.3 Wastewater Treatment Plant (WWTP)

For the study of the treatment plant, the characteristics of location, environment, sewerage and waste water to be treated is essential. The WWTP to be built corresponds to the Model 24A90. Photo 2 shows the installation plan and the different parts of the WWTP proposed by the company SEWPACKSA and can handle a volume of water equal to the daily production of waste of 500 people. The maximum daily production of the WWTP is estimated at 75 m3 / day. Photo 2 shows some WWTP equipment.

Photo 2 WWTP Componants

Photo 3 Some WWTP equipment Model 24A90

2.8.3.1 Technical characteristics of the WWTP

Wastewater produced at the mine site will be evacuated using a separate system. It will be built on the site for three types of sewerage wastewater:

- domestic wastewater;
- the waste water from the processing plant;
- the rainwater drainage network.

Furthermore, mobile latrines with septic tanks, built to international standards, will be installed on site during the construction phase. This phase will log the presence of 323 people permanently. The collected waste will undergo treatment before discharge.

2.8.3.2 Location of the WWTP

The WWTP is located in the northwest of the processing plant, 1 km from the camp. The site promotes the flow of water by gravity following treatment.

2.8.3.3 Sewerage

A sewer system is designed to route domestic waste to the treatment plant. This network sends the sewerage to the pumping station where it will be pumped and delivered to the WWTP.

2.8.3.4 Treatment steps

The treatment of domestic wastewater from the mine site will occur in three stages (**Table 2.18**):

Pre-treatment

The pretreatment is to do a screening, sieving, grit removal and a degreasing to remove the coarser materials that can damage mechanical components.

Initial treatment

The initial treatment allows for retention of settleable particles, allowing for a reduction in DCO and DBO_5.

Secondary treatment

The stage of secondary treatment is purely organic and will transform the soluble pollution into well settling biological sludge at a secondary clarifier or settling tank. At this stage there may be (if necessary) removal of carbon, nitrogen, and phosphorus pollutants.

The sludge from the treatment system can be sterilized by drying beds. The sand treatment plant and the water from the treatment plant will be discharged into the environment. Regular tests will be done to control the discharge quality.

Table 2.18 shows a simplified diagram of the processing station.

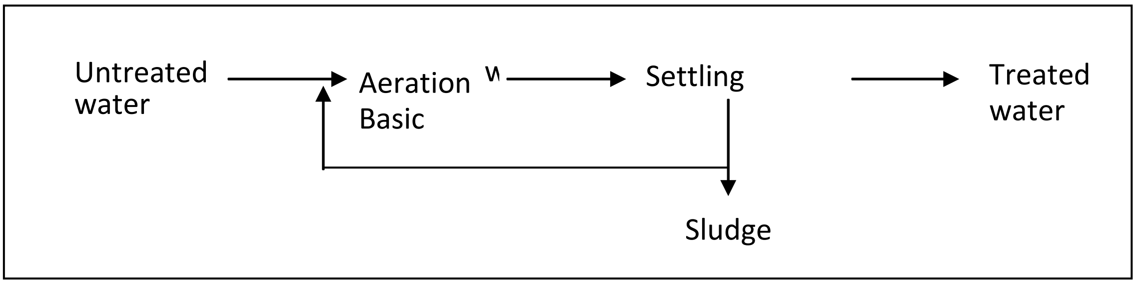


Table 2.18 Simplified diagram of the wastewater treatment plant (WWTP)

2.8.3.5 Quality of wastewater

The quality of domestic sewearge will be determined after the production of the first volumes of wastewater in order to optimize the treatment process that will be implemented. There will be an estimated population of about 323 people permanently on the site. The daily demand for drinking water is to be determined on the basis of a need for to 200 liters per person per day of drinkablle water for staff. From this data, daily water production to treat 64.6 m3 / day was obtained and corresponds to the maximum volume of wastewater to be treated daily by the WWTP. This daily rate is well below the daily processing capacity of the WWTP.

2.8.4 Camp

A mining camp will be located approximately 2.2 km southwest of the processing facilities and it will accommodate 130 employees and security agents not from the region.

The existing camp will be complemented by two rooms already available and will be used for the first accommodation pending the finish of the permanent camp.

The permanent camp will be used for Perseus staff and employees and any remaining capacity, if available, will be available for mining contractors.

During construction, contractors will have to provide their own accommodation for their personnel. An area adjacent to the construction site will be reserved for temporary camps for subcontractors. Some contractors may also find temporary housing in towns and villages nearby.

The camp is comprised of several buildings including:

- administration;
- housing units;
- toilets ;
- a football field and a gym;
- water treatment;
- parking lot;

Wastewater from the administration and camp can be divided into two groups: domestic sewerage and rainwater.

Domestic sewerage or wastewater is sourced from the mess, restrooms, locker rooms, offices and vehicle washing points. The wastewater will be drained through a sewer system to the wastewater treatment plant and undergo several processing steps to meet the discharge standards **Table 2.19** .

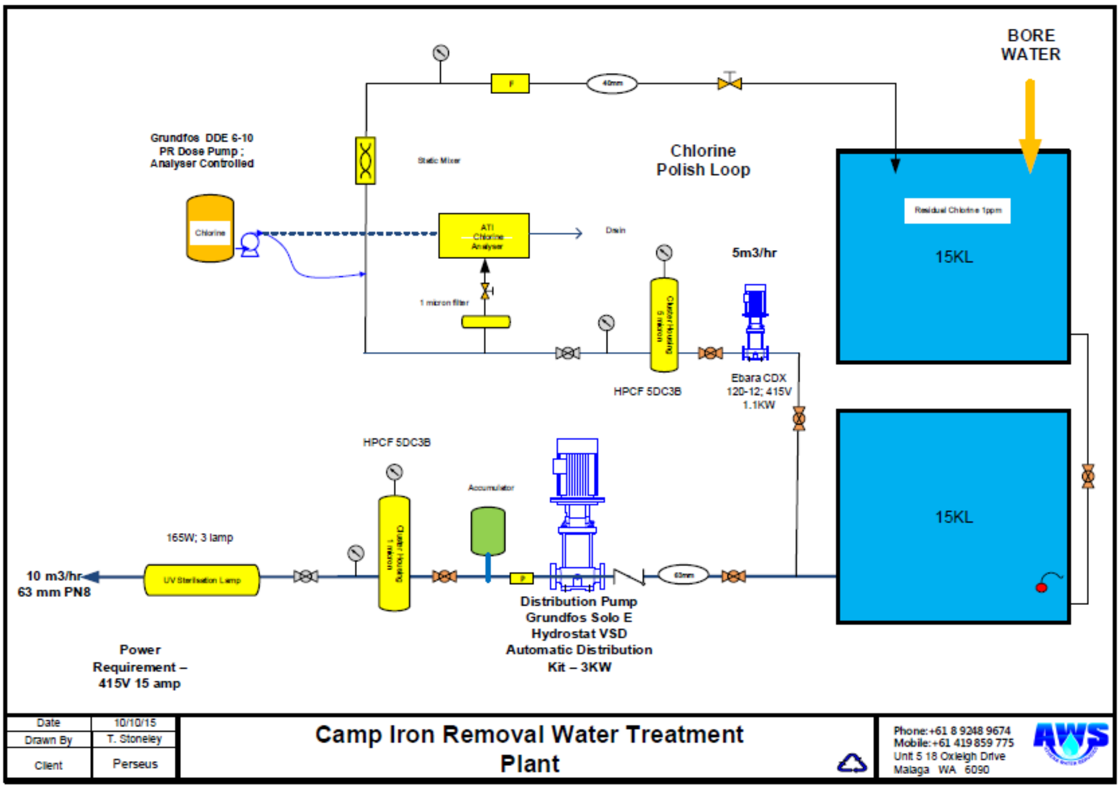


Table 2.19 Evacuation plan for camp wastewater to the wastewater pumping station

Regarding electricity, the study showed that for the first year of operation, the supply of electricity to the project should be done from a diesel generator. The national grid will take over from the second year. As for drinking water, it will be available on the site from a drilling production, with the treatment process is shown in **Table 2.20** below:

Table 2.20 A method of producing potable water on site

2.8.5 Tailings Storage and site water balance

2.8.5.1 *Production and description of the tailings site*

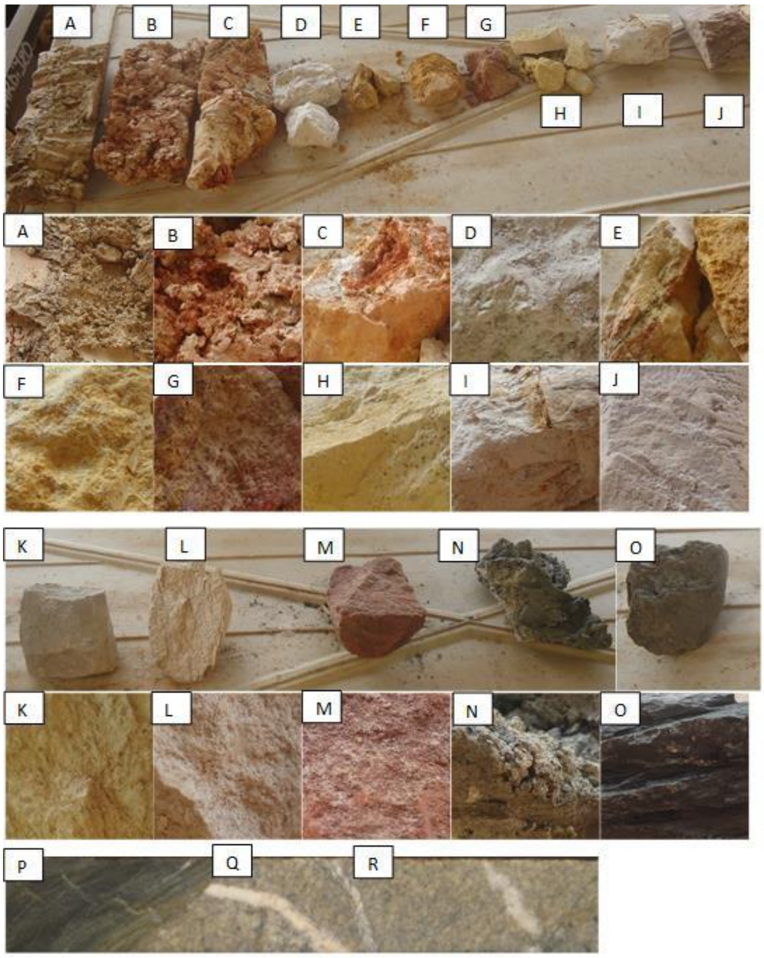
The tailings will be located north of the processing plant. This site of over 58 hectares is covered with shrub. It is used for livestock grazing. The laterite soil is sparse UHF blocks of ironstone (Photo 4). The thin layer of humus soil is covered by group of small termite mounds (about 15 cm high). This site was also chosen because of its topography plains and low altitude. The tailings site is located about one kilometer from the Bagoe River, which is one of the most sensitive components.

The lithology of the site (Photo 5) prepared from the core holes near the site reveals the top down:

- a first layer of clay and saprolitic lateritic from 0 to about 79 m;
- metamorphosed sediments (metasediments) consolidated from 79 to 210 m;
- granite to more than 201 m.

These surveys also intercept fracture zones containing local aquifier clay. (Photo 6).

Photo 4 **Landscape view of the proposed TSF site**



A: colluvial clay containing few pisolites (0 to 0.9m)
B: lateritic clay containing few pisolites (0.9 to 8.4m)
C: mottled clay (8.4m to 9.82m)
D, E, F, G, H, I, J: random arrangement of different colors of clay locally oxidized low in sand. Some traces of iron oxide (E and I) (9.82 to 29m)

K, L, M: oxidative sediment (79 to 134m)
N: argillaceous rocks in metasediment (127 to 147m)
O: Graphitic slate level (147 to 153m)
P: Unoxydised sediment (153 to 210m)
Q: Contact felsic sediment at 210m
R: Felsic rock 210 to 213m

Photo 5 Overview of lithology near the TSF core sampling SD293

Photo 6 Fracture Zone (aquifer) of 127 m to 153m survey SD293

2.8.5.2 Tailings Storage Facility (TSF)

The tailings storage facility (TSF), which will be located approximately 300 meters southeast of the operation, will receive the tailings, with about 43% solids (oxide) and 48% solids (primary). The WWTP will be used to meet the water needs of the processing plant.

The TSF has a nominal diameter of 1100 m, occupying a storage area of approximately 100 ha. The basin is surrounded by barren rock to form an integrated sterile terrain. The basin is a structure designed in clay to contain the tailings and minimize losses due to seepage. The TSF was designed to have a storage capacity 4 077 715 m3. At this stage, however, only 5.5 Mt will be introduced over a period of five years. The TSF will be constructed in two steps. The first step provides storage for 4.5 Mt and will initially be constructed using pre-stripping mine materials. The second stage will take place during the fourth year and use in stock oxidized tailings.

The discharge of mining waste will surround the TSF. A compacted clay area for mining waste will be built in the upstream portion (internal) of the TSF. Inside this area, is a clay structure designed in a geotechnical study and whose characteristics allow residues and minimize infiltration leaks. In addition to clays, smooth geomembrane of high density polyethylene (HDPE) which complies with the required international standards will be used under the supervision of a qualified subcontractor. Table **2.21** below shows the geomembrane system and settling of the TSF.

The TSF will benefit from a cladding system with respect to the old site if the geotechnical characteristics in the study require. In addition, a leak detection system will be installed to ensure better control of leaks. The storage volume ranges from 5.6 MT to 5.3 MT.

Table 2.22: General scheme of geomembrane system and settling of the TSF

2.8.5.3 Geotechnical characteristics of the TSF

A geotechnical study was undertaken at the sites of the processing plant and the TSF.

Three vertical holes were drilled approximately 200 m to 300 m, with a drilling rig supplied by Geodrill. Standard tests were carried out using the drilling apparatus at the required intervals in each borehole.

All holes were drilled from the ground surface using coring techniques. The cores were placed in core trays and recorded and photographed. They were later transported to the Tengrela camp for storage.

Drilling has identified highly altered rocks at a relatively shallow depth. The rock is worn to the point where it has the geotechnical properties of a very stiff hard clay. The degree of damage that has been found decreases with depth at each drilling location.

The tests were used to describe the soil conditions near the surface as follows:

- laterite was found from the surface between 4.5 and 6.0 m deep;
- from 6.0 to 4.5 m, laterite was found in a transition to a residual soil material less altered at a depth of 12.7 m in the three drill holes.
- below 12.7 m, the degree of damage was further reduced with depth.

Drilling and drill hole locations are summarized in **Table 2.23** following:

Table 2.23 Summary of drilling tests

Drilling	Depth (m)	Residual soil depth (m)	Depth of extremely weathered rock (m)
BH – 04	16.	4.8	12.7
BH – 05	25.	6.0	12.7
BH – 06	25.	4.5	12.7

In situ testing of the results from the three holes have concluded that the soil condition is favorable to the installation of TSF. However, some results are pending (due to the size, fractions and types of clays) and additional studies are needed during the construction phase of the works.

The TSF has been designed for a lifespan of 10 years with a nominal diameter of 1100 m. The construction will be done in 5 steps. Each step will require raising borders of 2 to 2.5 meters.

Observation wells (piezometers) and leak detectors will be placed around the dam for regular monitoring of the quality of groundwater.

2.8.5.4 Water balance

The water balance of the site indicates that sufficient water will be available for the life of the mine, even without drawing water from the Bagoé river. However, a permit will be gainted to complete the water level of the TSF if the volume falls below 400 000 m³.

The water balance model indicated that if production starts during the dry season, there should be enough water to operate the treatment plant, provided a sufficient starting volume is in the TSF basin, either from collected water taken from the river during the previous wet season, or from the pit dewatering.

Water balance is based on dewatering volumes of the pit 80 m³ / h, irrespective of the water used for the dust removal. Tests pump drilling for the proposed dewatering are still needed to confirm the rate expected flow rates.

2.8.6 Facilities

The connection point to the nearest grid is the substation of 225 kV in Boundiali. As connection is dependent on the addition of infrastructure to connect to the national grid in Tengrela this is not an attractive option. Electricity will be generated on site by a power station running on diesel, adjacent to the fuel storage facilities. The power station will feed the main high-voltage control room inside the mill room, from which the power is distributed. Four high speed generators of 1.6 MW 11 kV will be provided in acoustic containers, the 11 kV control room being provided in a container by a different vendor.

A modular processing unit of potable water comprising filtering, sterilization by ultraviolet radiation and chlorination, will be installed. Potable water will be retained in the reservoir and will be routed to the processing buildings, sanitation buildings, safety showers and other water points.

The waterwater from all the water facilities of the processing plant, the area of mining services and mining camp will be transported to the gravity wastewater systems. The wastewater from each zone will lead to a pumping station wastewater where it is poured through a pressurized main pipe to a waste water treatment system within the process plant.

The buildings on the site are industrial-type structures. The workshop and warehouse will be built on a concrete slab on the ground, with a structural steel frame and metal coatings. Offices and general services buildings will be prefabricated structures.

The following facilities will be located in a fenced area adjacent to the plants:

- Gatehouse with turnstile and barrier control;
- Weighbridge for control of fuel supplies and goods;
- Main administration building;
- Emergency care / clinic;
- Refectory for administrative workers;
- Warehouse and storeroom;
- Subcontractor laboratory;
- Power Station;
- Fuel storage equipment. ;
- Mining services area (facilities to be provided by the mining contractor).

The following buildings will be located in the high security zone:

- Secure access to building and changing rooms, including the laundry;
- Offices, training room, refectory and employee health centre;
- Workshop, including a small shop, a welding area and a crane;
- Engineering offices;
- Reactants storage area;
- Gold Room.

Internal communications and IT services on the site will be via a fiber optic network.

One of the local telephone companies will be used to install equipment on the site and provide a link to the local, national and international telecommunications network.

A radio network will be installed with dedicated channels for operations, safety and emergencies.

A sattelite dish will be installed to provide global satellite connection for calls and data.

2.9 IMPLEMENTATION OF THE PROJECT

The proposed approach for the Project implementation is to hire a firm, to study the engineering, procurement, plant construction, and project management, which will be transmitted to an operational team by the Project Owner, and hire an experienced mining contractor for the development of the mine infrastructure and implementation of continuous drilling services, blasting and ore extraction under the responsibility of the technical mining team of the Client.

The Client Team will be gradually recruited to expand its knowledge base and skills to meet the needs of the Project. The team of full-time and part-time employees will manage the activities of both local and overseas and specialized subcontractors, as well as provide specialized technical advice in the Project design.

The staff required for essential local mining operations will be hired to assist in mine design and manage the development of the mining infrastructure and open pit mining undertaken by the contractor.

The service department, management and administration of Perseus in the country will manage environmental and community issues, and prepare the site for the influx of the operational staff.

A preliminary schedule shows that the operation can be performed in the next 76 months. The important dates for the project are provided inTable 2.24.

Table 2.24 Operating schedule

Description of the important date	Schedule
Grant date	Week 0
Award of the contract	Week 14
Mobilization of the main contractor of civil and earthworks	Week 19
Opening buildings	Week 35
Mobilisation of SMP contractor	Week 38
Mobilisation of E&I contractor	Week 60
Commencement of the installation of mechanical	Week 63
Start-up	Week 60
First gold pouring	Week 76

Several elements and activities are potentially on schedule or close to the critical path of design and construction, in particular in regard to procurement, manufacturing, transportation and installation of major mechanical and electrical equipment items for treatment facilities. The flow chart will be discussed further before the first engineering work commences.

2.10 OPERATION

2.10.1 Transition to operation

By leveraging recent experience of Perseus in the startup of a new mine in Ghana, comprehensive regulations will be developed, and initiation procedures, training and operation will be implemented through a General Operational preparation plan to be prepared to ensure that the transition from the exploration phase of project development to the operations phase is done safely and effectively.

Perseus agrees to provide employment opportunities for Ivorian citizens, identifying people with the qualifications, experience and skills. However, it is expected that expatriate staff will complete a number of executive management roles, key supervision and training. Where possible, a succession plan will be developed for giving roles to Ivorians originally occupied by expatriates.

Job offers for expatriates will be published internationally and / or regionally, as Perseus sees fit, taking advantage of its established position as gold producer, with trained and experienced personnel in the neighboring country of Ghana.

It is acknowledged that the site is located far from the main areas of population. Arrangements were therefore made to use Ivorian nationality executives on a rotating basis. The jobs will be offered to residents where feasible and appropriate.

2.10.2 Increasing production

Mining and production estimates have been prepared to facilitate the development of a cash flow model and thus precisely determine the income flows and timing of spending.

The mining contractors will be engaged during the construction phase to enable the establishment of the mining services area, development of access roads and other mine infrastructure including the completion of the pre-stripping of the mine, the construction of the TSF and the Waste Rock Dump.

The schedule was developed to reflect the simple and robust scheme of the treatment plant, using data from similar regional operations. It is estimated that the optimum ore flow rate will be reached in the third month following the first introduction of the ore on the circuit.

Ore production for the life of the mine will be 5.5 Mt grading 2.4 g gold / t. Pre-stripping of the mine will commence five months before the start-up activity of the plant.

The ore processed during the first year of operations and again during a period of five months during Year 3, will come mainly from areas of oxidized and transitional material. During this period, the facility will be operated in a configuration with two stages of grinding / primary milling. In this configuration, treating soft materials, the factory has a nominal capacity of 1.2 Mt per year, providing a capacity to catch up on unexpected operational delays caused by ore handling problems.

Gradually, as the proportion of fresh ore increases in facilities, the spray system will be reconfigured to three-stage crushing and conventional ball milling, as the harder materials require a finer crush size to be submitted to ball milling. The reconfiguration of the grinding circuit is relatively simple and at the time when the output of the mine is a mixture of soft materials and fresh ore process, grinding plants can be alternately adjusted if necessary to process materials properties different.

2.10.3 Gold Production

Gold production for the life of the mine is estimated at 385 koz. The annual calendar of gold production from the plant commissioning appears in **Table 2.25**.

Table 2.25 Total Gold Production

Grinding month	**1-12**	**13-24**	**25-36**	**37-48**	**49-60**	**61-64**	**Total**
‘000 Ounces	67	82	61	74	93	8	385

2.11 OPERATING COSTS

2.11.1 Mining costs

2.11.1.1 Mining contractor

The mining contract costs for conventional operations of drilling, blasting, mining, and transportation have been developed from the estimate of the mining contractor, DTP Mining. The labor data for the management and supervision by the Perseus staff have been developed from an internal organizational structure. Mining costs have been developed with a confidence level of ± 25%.

Overall mining costs for the life of the project, expenditure of the mining contractor including the establishment, mobilization and demobilization, adjusted to include fuel costs at US $ 1.01 / L, appear in **Table 2.26**.

Table 2.26 Costs of the mining contractor for the life of the project

Mining Contractor Estimate						
Element	**Description of the element**	**Unit**	**Driver**	**Rate**	**Unit**	**Total M $ US**
1	Creation of the site	n°	1	3 609	1000 $ US	3.6
2	Fixed monthly sum	Month	65	512	1000 $ US	33.3
3	Preparation of the area	km2	796	0,88	$ US	0.7
4	Drilling	kdrm	172	22,4	$ US	3.8
5	Blasting	K pit	21.8	173	$ US	3.8
6	Digging, loading, carrying and	kbcm	10	3.63	$ US	39.5
7	Inventory overhaul	kt	5 525	0.60	$ US	3.3
8	Dewatering of the pit	Month	65	32.19	1000 $ US	2.1
9	Grade control	Kt ore	5 525	0.24	$ US	1.3
Total						**91.4**

The costs of the mining contractor incurred in the course of the five months preceding the processing of ore (11.05 million $) is covered in mine development costs.

For the duration of the project this equates to an average cost of $ 16.55 per tonne of ore or $ 8.42 / Bcm, or $ 3.95 / ton of rock.

2.11.1.2 Management and supervision by the owner

Management and supervision costs of the mine by the Client reach a total of $ 5.99 millionfor the life of the mine, including $ 0.53 million incurred during the pre-stripping.

2.11.2 Processing and administration costs

The estimate of overheads of the administration of operations for the life of the mine is presented in summary form in the **Table 2.27**. The estimate is considered to have a reliability of ± 15%, is presented in US dollars (US $) and is based on prices obtained in the first quarter 2014 (4Q14).

The general administration costs of operations include the administrative costs of the site and those of the Abidjan office. The company's expenses out of the Ivory Coast are excluded.

Table 2.27 Administrative and operational costs of the mine for its lifetime

Cost item	DE	
	$ US	**$ US /**
Electricity	39 867 729	7.22
Consumables	25 389 577	4.60
Maintenance	6 236 076	1.13
Laboratory	4 240 832	0.77
Labour, processing and maintenance	14 180 385	2.57
Processing ore	1 546 694	0.28
Total mining cost	**91 461 293**	**16.56**
Abidjan office	1 273 507	0.23
Administrative staff	13 539 305	2.45
General and administrative expenses	27 738 812	5.02
General and administrative total	**42 551 624**	**7.70**
Total costs	**134 012 917**	**24.26**

2.11.3 Investment Estimation

The investment estimate is summarized in **Table 2.28**. The initial cost of the capital project was estimated at US $105.98 million

Table 2.28 Summary of the estimated initial capital cost ($ US, Q1 2015 ± 15%)

Initial Investment		
Element	**Principal sector**	**Total US$**
1	Mining	11.89
2	Indirect construction costs	8.01
3	Treatment plant	21.75
4	Reagents and treatment services	8.43
5	Infrastructure and tailings	22.86
6	Costs of building owners	14.46
7	EPCM costs	9.18
8	Incedentals	9.40
Sub-total		**105.9**

The exclusions to the estimation of capital include the following:

- Pre-operating costs.
- Costs and tariffs it is assumed that the Project will be exempt from.
- Costs of compensation for land and community.
- Financing costs.
- Price increases.

2.11.4 Financial analysis

Mining Sissingue is an economically viable project with the current gold price. By applying a gold price of US $ 1,200 / ounce in the long term, for a horizontal scenario from the beginning of production, the cash flow is 112.4 million US $ before tax with repayment of the Project expected to occur after 2.7 years. The lifespan of the mine is estimated at 5.3 years.

There is an internal rate of return or IRR of 27% and a net present value NPV) of US $ 52.5 million, based on actual cash flows after tax calculated at a rate of 10%,

Production costs C1 'cash costs' for the life of the mine is US $ 570 / ounce, while the total costs, including maintenance capital costs are $ 632 US / oz (net cas income, 3 US $ / oz).

Profits are sensitive to gold price and content / ore recovery. For an increase of US $ 100 / ounce gold price, there is an added NPV of US $ 24.3 million, whereas with a decrease of US $ 100 / ounce gold price, the NPV is lessened by 26.1 million $ US (**Table 2.28**).

Table 2.29 Financial analysis

Gold prices	Unit	1 100 $ US /	1 200 $ US /	1 300 $ US /
Tailings and extracted ore	1000 $	23 183	23 183	23 183
Processed ore	1000 ozs	5 524	5 524	5 524
Ore grade	G gold / t	2.42	2,.2	2.42
Average recovery weight	%	89.72	89.72	89.72
Gold production	ozs	385 211	385 211	385 211
Development capital	1000 $	105 982	105 982	105 982
Capital support	1000 $	5 249	5 249	5 249
Mining costs	1000 $	85 835	85 835	85 835
Treatment costs	1000 $	91 461	91 461	91 461
Administration costs	1000 $	42 358	42 550	42 743
Cash cost of mine (C1)	$ / ounce	570	570	571
Cash costs years 1 and 2 (C1)	$ / ounce	596	596	597
Total cost	$ / ounce	628	632	643
Cash flow	1000 $	75 645	112 414	146 680
TRI	%	18.8	27	34.2
10 % VAN	1000 $	26 382	52 515	76 794
Repayment period	month	38	32	26
Taxes paid	1000 $	-	2	140
Royalties (State)	1000 $	17 258	18 798	22 42

2.12 RISKS AND OPPORTUNITIES

2.12.1 Risks

2.12.1.1 Risk of sovereignty

KPMG has released an analysis report covering the risk of sovereignty during the first quarter of 2013. At that time, none of the three main agencies for evaluation noted a risk of sovereignty in the country.

The KPMG report states that "the foreign interest in the Ivory Coast has recovered since the stabilization of the political environment, although political risk remains relatively high."

The sovereign risk is mitigated by the short period of reimbursement provided for the Project.

2.12.1.2 Border raids

The project site is adjacent to the border between Côte d'Ivoire and Mali. There is a possibility of security threats from individuals or groups entering from Mali and crossing the border back into Mali before the Ivorian authorities can react.

The non-violent attempts by individuals or groups interested in the theft of transportable goods such as vehicles, tools, copper wires, etc., will be discouraged by concentric lines of fixed security. Fences patrolled around the entire site will deter casual access and opportunistic theft. A second, more rigorous control access barrier will ensure that only employees and visitors have access to essential equipment and storage areas. A third double fence, with video surveillance and a new controlled level of access surround processing facilities. Finally, gold is processed and stored in a secure building with strict access control, intruder alarms and video surveillance.

The fixed safety equipment will be patrolled and monitored by a security team on site that will develop close working relationships with local Ivorian police and military personnel to gather information and respond to urgent cases.

The gold will be recovered weekly and quickly shipped off site by air. If possible, the days of casting and gold flight schedule will be randomly changed to discourage attempts of theft.

There will be no resistance in the unlikely event of an armed attack by an organized group.

2.12.2 Opportunities

2.12.2.1 Project timeline

The speedy development of the Project, at a time when construction activity in West Africa and elsewhere is well below recent peaks, offers the ability to negotiate competitive prices for supply contracts for equipment and construction. The project timing has the merit of reducing the risk of upsurge and cost overruns, reducing the risk of exceeding the amount of contingency reserves of the project. Once the project is underway it is likely that more favorable suppliers prices and prime contractor rates may be negotiated.

Discussions with DTP indicated a potential for reducing mining costs of the Project by 6 to 7% of their initial quote. The experience of the process of the recent tender to Edikan shows that the reduction could ultimately be more important because of the very competitive nature of the mining sector contractors.

2.12.2.2 Extending the life of the mine

Additional mineralized zones and larger leases in Tengrela could be identified and mined. Although this project is based on the mining of the Sissingue deposit, a possibility exists that the life of the mine is extended.

The drilling completed to date on the deposits of Mahale / Bele, 40 km southwest of Sissingue demonstrate a possibility for additional ore to mine. The deposit is located a close distance by road from the Sissingue mine. Additional work will be needed to develop the resources and reserves. The West Bele resources are estimated to contain approximately 10,000 ounces at 1.5 grams of gold per tonne, and the East Bele resources contain approximately 50,000 ounces at 2.5 grams of gold per tonne.

2.12.2.3 Power supply from the grid

Power supply from the grid is not the preferred option for Sissingue. There is a risk to the continuity of power supply in operations Perseus Edikan in Ghana, and a potential method of reducing this risk would be to access electricity in Ivory Coast through CI-Energy. As part of a potential agreement, Perseus could provide additional capital to finance the construction of the power line to the Boundiali site, and Perseus, as a whole, could benefit from such an arrangement. The power supply of the site by the network could potentially reduce Sissingue operating costs.

3.0 DESCRIPTION OF THE INITIAL STATE OF THE ENVIRONMENT

3.1 DEFINITION AND SELECTION OF THE STUDY AREA

The study of the initial state of the site and access roads summarizes the environmental knowledge of the area of the Sissingue gold project, which was established on the basis of detailed studies to characterize the different environmental compartments, namely the physical compartments, biological and human.

The various research works, conducted by experts from research firm CECAF International, started in April 2010. This study has also collected data on climate, air quality, noise levels, hydrology, hydrogeology, hydrobiology, chemical and biological quality of surface and ground waters, wildlife, soil, land use, community health, archeology and socio-economic conditions of the project area.

In general, for each aspect of the study of the initial state, the research has focused on the area corresponding to the main site of the project development and the scope chosen for the operating license. However, treatment of subjects such as sociology, climate and the aquatic environment sometimes needs to extend well beyond the scope of the investigations this study area and even beyond the border.

All these studies were conducted by national experts who have adopted methodologies based on scientific work protocols and systematic data collection.

The different sampling phases took place during the wet and dry seasons to account for seasonal differences.

This report presents the work of the initial state of the project area and includes the following parts:

- Atmospheric Environment (climatological study, air quality, water quality and noise level);
- Aquatic environment (hydrology, hydrogeology and Hydrobiology);
- Ecological environment (flora and fauna);
- Terrestrial Environment (soil science, land use and agriculture);
- The human environment (socio-economic and archeology);
- Environmental health (Community Health)

3.2 ATMOSPHERIC ENVIRONMENT

3.2.1 Climate

3.2.1.1 General Description

The project area, located in the north of the Ivory Coast is under the influence of tropical or Sudanese climate, with two seasons. The wet season is from mid-April to late October and the dry season from November to mid-April. During the wet season, maximum rainfall amounts occur from July to September with maximum (370 mm) in August and rainfall amounts between 1000 mm and 1600 mm. The dry season is characterized by high temperature variations, permanent haze, low cloud cover and the almost total lack of rainfall during the months of December, January and February.

3.2.1.2 Study methodology

The climatological study consisted of a summary and interpretation of the data provided by the National Meteorology Directorate (SODEXAM). The climatic data included: rainfall, temperature, relative humidity, sunshine, humidity and winds. Only a single synoptic station exists in the area in Korhogo.

The other positions only have a gauge as a measuring device. The information obtained is found in **Table 3.1**.

Table 3.1 Meteorological stations selected for study

Station	N° OMM	Distance from Sissingué (km)	Latitude North	Longitude West	Altitude (m)	Station Type	Opened
Tengrela	109001930	19.90	10°29 N	6°24	152	P	1953
Kanakono	109052800	8.82	10, 22 N	6°13	327	P	1976
Toumoukro	109002120	51.76	10°23 N	5°45	152	P	1971
Korhogo	109001200	127.63	9°25 N	5°37	381	S	1971
S : Synoptic Station, P: Precipitation Station							

3.2.1.3 Rainfall analysis

Analysis of the rainfall was made including the seasonal and monthly variability. For the purposes of this study, rainfall data recorded during the period 1953-1996 (44 years) for the Tengrela station and from 1979 to 1996 (18) Kanakono and Toumoukro stations was used. Annual rainfall varies between 658 mm (Tengrela) and 1531 mm (Toumoukro) with an estimated average of 1137 mm (**Table 3.2**).

Table 3.2 Annual rainfall in mm

Station	Period	Average	Minimum	Maximu	SD	Coeff.
Tengrela	1953-	1068	658	1452	196	0.18
Kanakono	1979-	1159	761	1473	184	0.16
Toumoukro	1979-	1172	892	1531	147	0.13

The monthly analysis of the data allowed the observation of a similarity in behavior between the stations and variations of the average monthly rainfall being in the same range. On the other hand, the monthly rainfall varies significantly from one year to another. The minimum, maximum and monthly averages are reported in **Table 3.3** below.

Table 3.3 Minimums, maximums and averages for each station in mm

Station	Paramete	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Tengrela (1953-1996)	Minimum	0.0	0.0	0.0	0.0	7.5	37.5	112.0	144.	45.9	0.0	0.0	0.0
	Maximum	48.3	40.0	97.6	128.6	278.2	269.	583.7	541.	468.	270.1	125.4	59.7
	Average	2.6	6.3	19.6	55.5	100.2	147.	261.8	318.	206.	85.3	22.3	4.7
Kanakono (1979-1996)	Minimum	0.0	0.0	0.0	2.5	58.5	68.3	116.4	127.	54.0	13.0	0.0	0.0
	Maximum	0.0	42.5	205.5	79.3	258.6	182.	314.5	320.	286.	76.0	31.9	0.0
	Average	0.0	7.9	42.5	54.2	148.6	135.	196.5	211.	182.	46.1	6.7	0.0
Toumoukro (1976-(1996)	Minimum	0.0	0.0	0.0	12.3	67.2	13.3	115.1	182.	58.9	15.1	0.0	0.0
	Maximum	0.0	57.3	80.8	145.3	197.4	228.	279.3	339.	205.	121.6	47.1	10.1
	Average	0.0	9.6	48.1	63.0	130.1	149.	190.3	236.	157.	67.0	10.0	1.7

Number of average annual days of rain varies between 54, 57 and 61, for Toumoukoro, Tengrela and Kanakono respectively. The two seasons that characterize the climate in this region of Côte d'Ivoire are well marked at the three stations, with a sharp decrease in rainfall from November that extends until mid-April and resumption of rains from mid-April to their major peak in August. The values of rainfall amount return periods are reported in**Table 3.4**.

Table 3.4 Daily maximum rainfall amounts (mm) according to the return period

Station	**Return period (years)**				
	2	**5**	**10**	**50**	**100**
Tengrela	79.8	104	119	154	168
Kanakono	75.9	98.5	114	147	161
Toumoukro	62	81	93.6	121	133

3.2.1.4 Temperatures

The minimum and maximum values for 1972 to 2000 for the Korhogo reference station, are presented in **Table 3.5**

Temperature variations (especially the maximum temperature) highlight the features of each particular season: the harmattan of the dry season and the monsoons of the wet season. The periodic and regular changes in systematic circulation give annual conditions of temperature at the same steady pace, which reflects the consistency and stability of this element in tropical latitudes.

Table 3.5 Korhogo temperature estimation parameters from 1972 – 2000.

Mois	Minimum Temperatures (°C)						Maximum Temperatures (°C)					
	Min	Max	Avg	Med	SD	CV	Min	Max	Avg	Med	SD	CV
January	16.6	20.7	18.7	18.7	1.14	0.06	32.2	35.4	338	33.9	0.81	0.02
February	19.3	22.9	21.0	21.1	0.88	0.04	34.2	39.7	35.8	35.9	1.02	0.03
March	21.3	24.5	22.6	22.6	0.77	0.03	34.4	38.5	35.6	35.8	0.94	0.03
April	21.7	24.5	23.0	22.9	0.61	0.03	28.6	36.7	34.6	34.5	1.46	0.04
May	21.1	23.9	22.2	22.2	0.61	0.03	22.3	34.4	33.0	32.5	2.18	0.07
June	20.0	22.2	21.2	21.1	0.61	0.03	29.8	32.5	30.7	30.9	0.72	0.02
July	19.7	21.6	20.9	20.8	0.54	0.03	28.2	30.7	29.3	29.4	0.58	0.02
August	19.7	30.4	20.9	21.1	1.86	0.09	28.3	30.2	29.4	29.3	0.49	0.02
September	19.3	21.9	20.5	20.6	0.55	0.03	28.7	30.9	30.1	30.0	0.53	0.02
October	19.7	21.7	20.7	20.8	0.49	0.02	29.7	33.6	31.8	31.8	0.74	0.02
November	18.1	21.5	20.1	20.1	0.80	0.04	31.1	34.4	33.7	33.4	0.81	0.02
December	16.2	20.5	18.5	18.4	0.89	0.05	32.0	35.6	33.3	33.4	0.84	0.03
SD : Standard deviation ; CV : coefficient of variation												

The harmattan creates some disruption during the dry season, but its effects are not as sensitive to the diurnal range and the maximum and absolute maximum temperatures. The range of the maximum temperature is 3.3 ° C greater than the average while the minimum values do not vary significantly (**Table 3.6**).

Table 3.6 Average maximum, average minimum and average temperatures of Korhogo from 1972-2000

Station (Period)	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Max (°C)	33.9	35.9	35.8	34.5	32.5	30.9	29.4	29.3	30	31.8	33.4	33.4
Average Min (°C)	18.7	21.1	22.6	22.9	22.2	21.1	20.8	21.1	20.6	20.8	20.1	18.4
Average (°C)	26.7	29.0	29.5	28.8	27.6	26.0	24.9	24.7	24.9	26.0	26.8	26.2

3.2.1.5 Evaporation

Evaporation is very important during the dry season with a peak in January (255 mm), which corresponds to the presence of the harmattan. By comparison, it is lower (<80 mm) during the wet season (**Table 3.7**).

Table 3.7 Average monthly Evaporation (E) in Korhogo in mm (1971-2000)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total /year
E (mm)	255.0	239.5	216.6	146.6	110.7	79.2	67.3	56.8	55.7	81.6	133.6	210.8	1653.4

3.2.1.6 Humidity

Average relative humidity varies between 31 and 77%, with a minimum in December and January and a maximum from June to September. The range of the minimum values is significant because they vary from 18 to 61.7% in contrast to the maximum values that remain consistent throughout the year with average values of 83% (**Table 3.8**)

Table 3.8 Average relative humidity (maximum and minimum) at Korhogo in % (1972-1997).

Month	Minimum Humidity (%)						Maximum Humidity (%)					
	Min	Max	Avg	Me	SD	CV	Min	Max	Avg	Med	SD	CV
January	11.2	26.7	17.9	18.0	4.12	0.23	33.8	75.0	44.2	49.9	13.37	0.27
February	10.0	35.7	19.8	19.4	5.49	0.28	35.7	78.9	57.7	55.6	11.15	0.20
March	16.7	37.3	28.6	28.7	5.41	0.19	51.2	85.5	74.5	73.0	9.18	0.13
April	28.2	49.6	40.9	41.3	5.32	0.13	76.3	92.5	87.0	86.3	4.00	0.05
May	40.2	58.2	49.7	49.4	4.55	0.09	88.3	94.7	91.2	91.6	2.01	0.02
June	50.4	62.3	55.6	56.3	3.24	0.06	90.0	96.7	94.9	94.2	1.70	0.02
July	53.9	66.6	60.0	60.2	3.01	0.05	92.7	97.0	95.0	95.2	1.20	0.01
August	55.5	68.5	61.6	61.7	3.35	0.05	94.2	97.6	96.0	96.0	1.11	0.01
September	52.4	63.7	58.6	58.3	3.20	0.05	93.5	97.9	96.6	96.2	1.36	0.01
October	42.2	56.3	48.7	49.1	4.00	0.08	90.8	97.4	94.5	94.7	1.63	0.02
November	23.6	40.1	31.5	32.4	4.55	0.14	81.1	93.4	87.6	87.5	3.37	0.04
December	15.8	33.5	21.3	22.0	4.33	0.20	52.0	81.5	64.6	65.4	8.43	0.13

3.2.1.7 Winds

The maximum and minimum averages monthly wind speeds are 3.1 m / s (11.16 km / h) and 2.1 m / s (7.56 km / h) respectively.

3.2.2 Measurement of sound levels

The environment of the study area is quite noisy during the day between 8 am and 6 pm, but the high noise levels are generally below the threshold of 70 dB (A). These levels are produced by motorcycles noises, cars and trucks. In some localities, this noisiness continues up to 8pm. The highest values recorded from 8am to 8pm in different localities are between 60 and 80 dB (A).

Beyond 8pm, the levels are generally low with values close to 50 dB (A). The maximum recorded values are above those proposed by the World Bank (55-70 dB (A)) and the Ivorian regulation (40-60 dB (A)). However, these noise levels do not occur continuously. The nights are relatively quiet with sound levels around 50 dB (A). Moreover, the noise levels obtained in the localities of the operating site during the same period are between 40 and 58 dB (A). In the localities of Basso and Border Ivory Coast-Mali, the noise continues up to 9pm with values between 70 and 80 dB (A).

In general, the study area can be regarded as consistent with some variation in typology in terms of noise as specified by the Ministry of Environment and Sustainable Development (**Table 3.9**).

Table 3.9 Allowable emission levels (in decibels) by type of activity

Zones	Time of day		
	Day	Interim Period	Night
Residential or rural areas with low ground traffic, river or air traffic	45	40	35
Urban residential area with few shops or business centers or with ground traffic lanes, fairly large river or air or in rural communities.	60	55	45
Predominantly commercial activities area	70	65	50
Predominantly industrial area	75	70	60

3.2.3 Air quality

3.2.3.1 Overview

The area and the two access roads to the site are entirely rural. There is no industrial source of air pollution with the exception of diesel emissions fumes. However, each year the harmattan winds spread the region with huge amounts of fine dust particles. This seasonal pollution, although specific to this geographical area of the continent, occurs during the dry season, from December to March. During this period, it is not unusual to have days where the concentration of airborne particles exceeds the standard set by O.M.S. which is 500 micro-grams of dust per cubic meter of air (500 g / m3).

Vehicle movements to a few villages in the area or in the Project can be seen as a largely intermittent and localized source.

3.2.3.2 Measurement of airborne polluants

Pollution from fine particles of dust is mainly caused by transport equipment on unpaved roads and has not reached an alarming threshold. All values obtained are around the level of 1000 mg / m2 / day limit between weakly polluted environments (≤ 1000 mg / m2 / day) and those that are highly polluted (> 1000 mg / m2 / day). In areas that are not on the edge of the two main roads (operation site and Djoguenesso), the quantities of dust are very low. However, the quantities of the highest dust are observed in Tiongoly with a value of 2205.07 mg / m2 / d; well above the threshold value.

The results of analysis of chemical pollutants (TVOC, CO, SO2 and H2S) illustrated by **Table 3.10** show that the levels of pollutants recorded both at the operating site and in the surrounding villages are extremely low. The air quality in relation to pollutants is excellent and meets the air quality standards and health protection in accordance with WHO limits and EH40.

Table 3.10 Analysis of chemical pollutant

Measuring points	Parametres	Average	SD	Maximum	Village entrance	Inside the village	Village exit	Limits (WHO and EH40) (ppm)
Village of DANZOUROU (morning)	**COV Total (ppm)**	0.0043	0.1316	2.3	0.008	-	0	5-10
	CO (ppm)	0	0	0	0	-	0	30 (VEMP) ; 200 (VECD)
	H_2S (ppm)	0.07	0.055	0.2	0.072	-	0.069	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0059	0.171	2.9	0.011	-	0	2 (VEMP) ; 5 (VECD)
Village of DANZOUROU (afternoon)	**COV Total (ppm)**	0	0	0	0	0	0	5-10
	CO (ppm)	0.068	0.13	2	0.066	0.064	0.072	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.035	0.048	0.2	0.043	0.02	0.041	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.001	0.014	0.02	0.001	0.000	0.002	2 (VEMP) ; 5 (VECD)
	COV Total (ppm)	0.02	0.4	5.9	0.040	-	0	5-10
	CO (ppm)	0	0	0	0	-	0	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0527	0.0506	0.2	0.056	-	0.049	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.026	0.52	6.67	0.052	-	0.002	2 (VEMP) ; 5 (VECD)
Village of KOTOU (afternoon)	**COV Total (ppm)**	0	0	0	0	0	0	5-10
	CO (ppm)	0.0313	0.2698	4	0	0	0.072	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0711	0.0533	0.2	0.062	0.068	0.078	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.0497	0.0373	0.15	0.038	0.025	0.032	2 (VEMP) ; 5 (VECD)
Village of POUROU (morning	**COV Total (ppm)**	0.0005	0.02	0.6	0	-	0.001	5-10
	CO (ppm)	0	0	0	0	-	0	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0462	0.05	0.2	0.056	-	0.035	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.0006	0.026	0.8	0	-	0.001	2 (VEMP) ; 5 (VECD)
Village of POUROU (afternoon)	**COV Total (ppm)**	0	0	0	0	0	0	5-10
	CO (ppm)	0.0277	0.2535	5	0.056	0.024	0.015	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0466	0.0508	0.2	0.010	0.057	0.064	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.0326	0.0332	0.3	0.007	0.040	0.045	2 (VEMP) ; 5 (VECD)

Measuring points	Parametres	Average	SD	Maximum	Village entranc	Inside the	Village exit	Limits (WHO and EH40) (ppm)
Village of KANAKONO (morning)	COV Total (ppm)	0.0002	0.006	0.5	0.000	0.000	0.000	5-10
	CO (ppm)	0.3026	0.6	20	0	0.004	0.053	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0538	0.05	0.5	0,045	0.063	0.532	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.0002	0.0078	0.65	0,000	0	0.000	2 (VEMP) ; 5 (VECD)
Village of SISSINGUE (morning)	COV Total (ppm)	0	0	0	0	0	0	5-10
	CO (ppm)	0.0193	0.7666	33	0.058	0	0	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0494	0.0553	0.3	0.083	0.083	0.003	10 (VEMP) ; 15 (VECD
	SO_2 (ppm)	0.0428	0.3594	0.6	0.003	0	0	2 (VEMP) ; 5 (VECD)
Village of SISSINGUE (afternoon)	COV Total (ppm)	0	0	0	0	-	-	5-10
	CO (ppm)	0.037	0.3793	6	0.037	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0333	0.0481	0.2	0.033	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0233	0.0036	0.4	0.023	-	-	2 (VEMP) ; 5 (VECD)
Village of MBASSO (morning)	COV Total (ppm)	0	0	0	0	0	0	5-10
	CO (ppm)	0	0	0	0	0	0	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0717	0.0477	0.2	0.072	0.068	0.072	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	0	0	2 (VEMP) ; 5 (VECD)
	COV Total (ppm)	0.0003	0.0174	0.9	0	0.001	0	5-10
	CO (ppm)	0.1818	1.4131	34	0	0.203	0.342	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0573	0.0592	0.3	0.026	0.049	0.096	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0043	0.006	0.01	0.007	0.001	0	2 (VEMP) ; 5 (VECD)
Village of DJOGUENESSO (morning)	COV Total (ppm)	0	0	0	-	0	-	5-10
	CO (ppm)	0.1098	1.6315	32	-	0.109	-	30 (VEMP); 200 (VECD
	H_2S (ppm)	0.0449	0.0512	0.02	-	0.044	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0314	0.0358	0.075	-	0.031	-	2 (VEMP) ; 5 (VECD)

Measuring points	Parametres	Average	SD	Maximu m	Village entranc	Inside the	Village exit	Limits (WHO and EH40) (ppm)
Village of TIALAKA (morning)	**COV Total (ppm)**	0.1464	0.3249	191	0	0	0.3576	5-10
	CO (ppm)	0	0	0	0	0	0	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0772	0.073	0.9	0.0873	0.498	0.0846	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.09	0.2746	1.2	0.082	0.066	0.122	2 (VEMP) ; 5 (VECD)
BAGOUÉ river (morning)	**COV Total (ppm)**	0	0	0	-	-	-	5-10
	CO (ppm)	0.1051	0.0194	1	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0926	0.0668	0.3	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0024	0.0526	0.3	-	-	-	2 (VEMP) ; 5 (VECD)
BAGOUÉ river (afternoon)	**COV Total (ppm)**	0	0	0	-	-	-	5-10
	CO (ppm)	0.2903	2.9487	42	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0564	0.0703	0.6	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0066	0.0455	0.3	-	-	-	2 (VEMP) ; 5 (VECD)
Mine site (morning)	**COV Total (ppm)**	0	0	0	-	-	-	5-10
	CO (ppm)	0.0023	0.0483	1	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.1046	0.0609	0.2	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0		0	-	-	-	2 (VEMP) ; 5 (VECD)
	COV Total (ppm)	$3,1x10^{-5}$	0.0017	0.1	-	-	-	5-10
	CO (ppm)	0.2409	1.2574	15	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.067	0.0693	0.3	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	-	-	-	2 (VEMP) ; 5 (VECD)
Village of Ziékoundougo u (morning)	**COV Total (ppm)**	0	0	0	0	0	0	5-10
	CO (ppm)	0.0026	0.15	0.9	0.0078	0	0	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0032	0.068	0.3	0.0037	0.0028	0.0031	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.00043	0.0087	0.65	0.0013	0	0	2 (VEMP) ; 5 (VECD)
	COV Total (ppm)	0	0	0	0	0	0	5-10
	CO (ppm)	0.053	0.10	1.5	0.053	0.048	0.058	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.032	0.058	0.4	0.034	0.025	0.036	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0009	0.017	0.023	0.0009	0.0006	0.0011	2 (VEMP) ; 5 (VECD)

Measuring points	Parametres	Average	SD	Maximum	Village entranc	Inside the	Village exit	Limits (WHO and EH40) (ppm)
Village of Tiongoly (morning)	**COV Total (ppm)**	0.0028	0.535	1.9	0.0041	0	0.0043	5-10
	CO (ppm)	0.223	0.81	6.9	0.271	0.124	0.274	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0429	0.056	0.2	0.0572	0.011	0.0605	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0225	0.0332	0.17	0.0238	0.0205	0.0231	2 (VEMP) ; 5 (VECD)
Village of Tiongoly (afternoon)	**COV Total (ppm)**	0	0	0	0	0	0	5-10
	CO (ppm)	0.0471	0.1553	4	0.0756	0.0492	0.0167	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0041	0.039	0.35	0.0057	0.0023	0.0045	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0002	0.0075	0.60	0.0003	0	0.0004	2 (VEMP) ; 5 (VECD)
Village of Basso (morning)	**COV Total (ppm)**	0.0002	0.0058	0.47	0.0003	-	0.0004	5-10
	CO (ppm)	0.0098	0.9	**23**	0.0074	-	0.0221	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0246	0.025	0.29	0.033	-	0.041	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.00015	0.0045	0.32	0.0001	-	0.0002	2 (VEMP) ; 5 (VECD)
Village of Basso (afternoon)	**COV Total (ppm)**	0	0	0	0	-	0	5-10
	CO (ppm)	0.0009	0.0037	3.8	0.0012	-	0.0017	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.017	0.06	0.11	0.018	-	0.016	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	0	2 (VEMP) ; 5 (VECD)
Village of Papara (morning)	**COV Total (ppm)**	0.0006	0.03	0.5	0.0011	0.0007	0	5-10
	CO (ppm)	0.0068	0.32	7	0.0071	0.0067	0.0065	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	0	0	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	0	0	2 (VEMP) ; 5 (VECD)
	COV total (ppm)	0	0	0	0	0	0	5-10
	CO (ppm)	0.0032	0.27	3	0.0035	0.004	0.0022	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	0	0	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	0	0	2 (VEMP) ; 5 (VECD)
Village of Doubasso (morning	**COV Total (ppm)**	0.0066	0.2	5.3	0	0.0095	0.0105	5-10
	CO (ppm)	0.056	0.8	4	0.054	0.047	0.068	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.00033	0.0008	0.004	0.0004	0	0.0006	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0002	0.0006	0.002	0.0003	0	0.0001	2 (VEMP) ; 5 (VECD)

Measuring points	Parametres	Average	SD	Maximum	Village entranc	Inside the	Village exit	Limits (WHO and EH40) (ppm)
Village of Doubasso (afternoon)	COV Total (ppm)	0	0	0	0	0	0	5-10
	CO (ppm)	0.038	0.32	2	0.042	0.029	0.043	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	0	0	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	0	0	2 (VEMP) ; 5 (VECD)
Village of Zanikan (morning)	COV Total (ppm)	0	0	0	0	-	0	5-10
	CO (ppm)	0.0096	0.15	1.92	0.017	-	0.012	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0		0	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	0	2 (VEMP) ; 5 (VECD)
Village or Zanikan (afternoon)	COV Total (ppm)	0	0	0	0	-	0	5-10
	CO (ppm)	0.0096	0.15	1.92	0.01	-	0.034	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0003	0.0018	0.003	0.0002	-	0.0003	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	0	2 (VEMP) ; 5 (VECD)
Village of Gbini I (morning)	COV Total (ppm)	0	0	0	0	-	0	5-10
	CO (ppm)	0.06	0.29	2	0.085	-	0.096	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0017	0.036	0.04	0.0023	-	0.003	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	0	2 (VEMP) ; 5 (VECD)
Village of Gbini I (afternoon)	COV Total (ppm)	0	0	0	0	-	0	5-10
	CO (ppm)	0.0077	0.2	0.57	0.0077	-	0.0076	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	-	0	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	0	2 (VEMP) ; 5 (VECD)
Village of Gbini II (morning)	COV Total (ppm)	0	0	0	0	-	-	5-10
	CO (ppm)	0.0001	0.0065	0.089	0.0001	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0	-	-	2 (VEMP) ; 5 (VECD)
	COV Total (ppm)	0	0	0	0	-	-	5-10
	CO (ppm)	0.0001	0.0059	0.073	0.0001	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0	0	0	0	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0	0	0			2 (VEMP) ; 5 (VECD)

Measuring points	Parameters	Average	SD	Maximum	S 1	Maximum S1	S 2	Maximum S2	S3	Maximum S 3	S4	Maximum S4	Limits (WHO and EH40) (ppm)
DIAMOND TRILEX Dilling site (morning)	**COV Total (ppm)**	0.35	1.2	25.3	0.7003	25.3	0	0	-	-	-	-	5-10
	CO (ppm)	0.1782	1.15	36	0.2998	36	0.0566	4	-	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.1005	0.0735	0.5	0.0994	0.5	0.1099	0.4	-	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0	0.0455	0.136	0.4	0.9103	0	0	-	-	-	-	2 (VEMP) ; 5 (VECD)
RAB Dilling site (afternoon)	**COV Total (ppm)**	0	0	0	0	0	0	0	-	-	-	-	5-10
	CO (ppm)	0.0253	0.012	2	0	0	0.0506	2	-	-	-	-	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0866	0.06	0.3	0.0884	0.2	0.0849	0.3	-	-	-	-	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0006	0.002	0.01	0	0	0.0012	0.01	-	-	-	-	2 (VEMP) ; 5 (VECD)
Mine Site (afternoon)	**COV Total (ppm)**	0.0009	0.0232	1.5	0.0019	1.5	0	0	0	0	0	0	5-10
	CO (ppm)	0.1629	0.3545	3	0	0	0.3259	3	0.5714	3	0	0	30 (VEMP); 200 (VECD)
	H_2S (ppm)	0.0684	0.06	0.2	0.0567	0.2	0.0801	0.2	0.0714	0.1	0.0937	0.3	10 (VEMP) ; 15 (VECD)
	SO_2 (ppm)	0.0011	0.0301	1.95	0.0024	1.82	0.056	0.3	0	0	0	0	2 (VEMP) ; 5 (VECD)

VEMP: Weighted average fair value ; VECD: Short term fair value

S: Sample

3.2.4 Water quality

Water sampling was carried out during the dry season and the wet season. Assessment of groundwater quality was made according to WHO drinking water quality guidelines. Also, the standards of the World Bank were used for surface water.

Map 1 shows the distribution of the sampling points of the surface and ground water in the localities concerned.

Map 1 Distribution of sample points of surface water and groundwater

3.2.4.1 Surface water

Physical and chemical properties

The surface water of the project area has different characteristics in the two seasons (**Table 3.11**). PH values are weakly basic (7.23-8.5). Moreover, the concentration of total suspended solids (170 mg / l) obtained in the Pourou dam during the dry season is higher than the discharge standard (50 mg / l) indicated by the World Bank. This favors an increase in turbidity (215 NTU) at this station. The concentrations of COD (<25-100 mg / l) and BOD5 (<5 mg / l), are below the World Bank threshold values, which are 250 mg / l, respectively for COD and 50 mg / l for BOD5. Surface water is substantially free of trace metals in addition to iron (0.6 - 9.1 mg / l), manganese (0.04 - 0.16 mg / l) and aluminum (0.22 – 9.7mg / l).

3.2.4.2 Groundwater

Physical and chemical properties

Groundwater is characterized by hardness and low mineralization, with a pH close to neutral. These waters have low concentrations and traces of nitrite. The majority of heavy metals in were only found in trace amounts in the samples analyzed. Only iron, manganese and aluminum were measured, but in low concentrations that are always below the WHO drinking water standards.

Bacterial properties

The analysis of the microbiological quality of groundwater revealed contamination of well water in the project area. Groundwater contamination sources can be different. WHO standards require the complete absence of germs in drinking water.

Compared to surface water, groundwater is of better quality and is suitable for consumption in terms of quality guidelines for drinking water (WHO standards) (**Table 3.11**). Surface water is exposed to pollution that could be important given their greater exposure to human activities.

In the current state, there is a moderate organic pollution in relation to microbiological pollution. Overall, they are weakly mineralized with concentrations of dissolved salts and relatively low conductivities.

Table 3.12 Results of analyzes of samples taken from surface water

Properties	SPSW1		SBORKSW1		SSSW1		World Bank
	DS	WS	DS	WS	DS	WS	
Physical properties							
Temperature	33.2	30	29,8	27	31,2	27,7	
pH	8.58	7.57	7,65	7,35	7,55	27,7	6,0-
Colour appearance	15	10	<5	15	<5	15	
Real colour	10	5	<5	5	<5	5	
Turbidity	215	34	2,3	86	2,6	82	
Dissolved solids	76	43	35	22	41	26	
Suspended	170	47	2	23	<1	23	50
Conductivity	10.3	6.2	5,1	3,9	5,7	4,2	
Chemical properties and nutrients							
Hardness	<5	10	9	15	8	9	
Alkalinity	33	23	21	13	22	16	
Nitrates (NO_3)	8.06	<0.06	<0,06	0,48	0,41	0,28	
Nitrites (NO_2)	<0,05	0.19	<0,05	0,06	<0,05	<0,05	
Calcium (Ca^{++})	<1	2	2	2	2	2	
Magnesium (Mg^{++})	0.8	1.2	1,3	2,4	1	1	
Phosphates (PO_4)	0.27	0,09	0,09	<0,02	<0,02	0,08	
Chlorides	6	1.6	0,5	2,2	0,6	1,9	
Sodium (Na)	8.3	3	4,4	3	4,7	3	
Potassium (K)	14	6.6	2,5	2,2	2,2	2,4	
Sulfates (SO_4)	8	<1	<1	4	<1	4	
DCO	100	38	<25	<25	<25	<25	250
DBO_5	<5		<5		<5		50
Heavy metals							
As (Total -	(0.002 ; <0.002)	0.002	(0,002 ; <0,002)	0,002	(0,002 ; <0,002)	0,002	0,1
Sb (Total -	(<0.003 ;		(<0,003 ;		(<0,003 ;		
Se (Total)	<0.003		<0,003		<0,003		0,1
Hg(Total -	(<0.001 ;	<0.001	(<0,001 ;	<0,001	(<0,001 ;	<0,001	0,01
Fe (Total)	9,1	2.1	0,9	4,5	0,6	4,6	3,5
Mn (Total)	0,16	0.05	0,09	0,04	0,06	0,05	
Cu (Total)	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	0,5
Zn (Total)	<0,05	<0.05	0,07	<0,05	<0,05	<0,05	2
Pb (Total)	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	0,1
Cr (Total)	0,02	<0,01	0,02	<0,01	0,01	<0,01	0,1
Ni (Total)	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	0,5
Cd (Total)	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	0,1
Al (Total)	5,47	1,19	0,58	9,7	0,22	6,86	
Mo (Total)	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	
Co (Total)	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	
Oils and fats	<0,1		<0,1		<0,1		
Microbiological properties							
Total coliforms at 37°C/24h	Present	Absent	Present	Present	Present	Present	0
Fecal coliform at 44°C/24h	Present	Absent	Present	Present	Present	Present	<400

NB : the concentrations are expressed in mg / l with the exception of pH, color (platinum / cobalt), temperature (° C), turbidity (NTU) and of the conductivity (mS / m), hardness (mg / l CaCO3), alkalinity (mg / l CaCO3) discharge standards of the World Bank (WB); DS: Dry season, WS: Wet Season.

Table 3.13 Results of analyzes of samples from Danzourou groundwater

Properties	SDGW1		SDGW2		WHO Standards
	DS	WS	DS	WS	
Physical properties					
Temperature	32.8	31.6	28.9	28.6	
pH	7.12	7.25	6.56	6.81	6.5-8.5
Colour appearance	5	15	<5	<5	
Real colour	<5	5	<5	<5	15.5
Turbidity	32	100	0.7	4.6	5
Dissolved solids	180	194	43	35	1000
Suspended materials	5	21	<1	6	
Conductivity	25	26.2	6.5	5	
Chemical properties and nutrients					
Hardness	72	76	8	<5	500
Alkalinity	116	115	20	11	
Nitrates (NO_3)	<0.06	<0.06	4.93	8.84	50
Nitrites (NO_2)	<0.05	<0.05	0.07	0.05	3
Calcium (Ca^{++})	14	15	1	1	
Magnesium (Mg^{++})	9.2	9.2	1.3	0.6	
Phosphates (PO_4)	<0.02	<0.02	<0.02	0.05	
Chlorides	<0.1	2.4	<0.1	<0.1	250
Sodium (Na)	19	19	5.4	5.1	200
Potassium (K)	4	3.5	3.2	2	
Sulfates (SO_4)	<1	<1	<1	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.004 ; <0.002)	0.002	(0.002 ; <0.002)	0.002	0.01
Sb (Total - dissolved)	(<0.003 ; <0.003)		(<0.003 ; <0.003)		0.005
Se (Total)	<0.003		<0.003		0.01
Hg (Total - dissolved)	(<0.001 ; <0.001)	<0.001	(<0.001 ; <0.001)	<0.001	0.001
Fe (Total)	5.7	7.4	0.3	<0.1	0.3
Mn (Total)	0.11	0.17	1.05	<0.02	0.5
Cu (Total)	<0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.13	0.1	<0.05	<0.05	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.01	<0.01	1.02	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.002	<0.002	0.003
Al (Total)	0.92	<0.03	1.48	0.18	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total coliform at 37°C/24h	Absent	Absent	Present	Present	0
Fecal coliform at 44°C/24h	Absent	Absent	Present	Absent	0

Table 3.14 Results of analyzes of samples from Kotou groundwater (continued)

Properties	SKGW1		SKGW2		WHO Standards
	SS	SP	SS	SP	
Physical properties					
Temperature	29.7	29.5	30.4	30	
pH	6.3	6.89	7.9	7.1	6.5-8.5
Colour appearance	5	5	<5	<5	
Real colour	<5	<5	<5	<5	15.5
Turbidity	6.4	18	5.1	8.1	5
Dissolved solids	13	22	152	142	1000
Suspended materials	8	21	13	18	
Conductivity	1.8	3.5	21.1	18.7	
Chemical properties and nutrients					
Hardness	<5	11	65	58	500
Alkalinity	5	13	99	89	
Nitrates (NO_3)	0.6	0.87	<0.06	0.07	50
Nitrites (NO_2)	<0.05	0.06	<0.05	<0.05	3
Calcium (Ca^{++})	<1	4	11	9	
Magnesium (Mg^{++})	<0.5	<0.5	9.1	8.6	
Phosphates (PO_4)	<0.02	0.06	0.32	0.04	
Chlorides	<0.1	<0.1	<0.1	<0.1	250
Sodium (Na)	0.9	0.6	11	9.9	200
Potassium (K)	0.5	0.6	2.5	2.3	
Sulfates (SO_4)	<1	<1	2	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002)	0.002	(0.004 ; <0.002)	0.002	0.01
Sb (Total - dissolved)	(<0.003 ;		(<0.003 ;		0.005
Se (Total)	<0.003		<0.003		0.01
Hg (Total - dissolved)	(<0.001 ;	<0.001	(<0.001 ;	<0.001	0.001
Fe (Total)	0.9	0.5	1	0.5	0.3
Mn (Total)	0.09	0.03	0.07	0.04	0.5
Cu (Total)	<0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.07	<0.05	0.1	<0.05	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.01	<0.01	0.02	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.002	<0.002	0.003
Al (Total)	0.48	0.63	0.72	0.29	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total Coliforms at 37°C/24h	Present	Present	Absent	Absent	0
Fecal Coliforms at 44°C/24h	Present	Present	Absent	Absent	0

Table 3.15 Results of analyzes of samples from Pourou groundwater (continued)

Properties	SPGW1		SPGW2		WHO Norms
	DS	WS	DS	WS	
Physical properties					
Temperature	30.1	29.9	29.8	29.6	
pH	6.93	6.95	6.85	6.84	6.5-
Colour appearance	<5	<5	<5	<5	
Real colour	<5	<5	<5	<5	15.5
Turbidity	0.4	0.2	1.5	1.2	5
Dissolved solids	130	132	122	136	1000
Suspended materials	<1	<1	<1	2	
Conductivity	16.9	17.4	15.8	18	
Chemical properties and nutrients					
Hardness	42	44	37	43	500
Alkalinity	80	79	68	71	
Nitrates (NO_3)	0.06	<0.06	1.88	5.91	50
Nitrites (NO_2)	<0.05	0.05	<0.05	0.08	3
Calcium (Ca^{++})	9	10	9	11	
Magnesium (Mg^{++})	4.6	4.7	3.6	3.8	
Phosphates (PO_4)	1.14	1.05	0.87	0.59	
Chloride	<0.1	<0.1	0.5	1.7	250
Sodium (Na)	15	21	18	20	200
Potassium (K)	4.4	4	4.4	4.2	
Sulfates (SO_4)	<1	<1	<1	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002)	0.002	(<0.002 ;	0.002	0.01
Sb (Total - dissolved)	(<0.003 ;		(<0.003 ;		0.005
Se (Total)	<0.003		<0.003		0.01
Hg (Total - dissolved)	(<0.001 ;	<0.001	(<0.001 ;	<0.001	0.001
Fe (Total)	<0.1	<0.1	0.3	<0.1	0.3
Mn (Total)	0.02	0.02	<0.02	<0.02	0.5
Cu (Total)	<0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.06	<0.05	0.11	0.07	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.02	<0.01	0.01	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.002	<0.002	0.003
Al (Total)	0.15	<0.03	0.33	<0.03	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total coliforms at 37°C/24h	Absent	Absent	Present	Present	0
Fecal coliforms at 44°C/24h	Absent	Absent	Present	Present	0

Table 3.16 Results of analyzes of samples from Sissingue groundwater (continued)

Properties	SSGW1		SSGW2		WHO Norms
	DS	WS	DS	WS	
Physical properties					
Temperature	27.9	27.6	28.6	28.5	
pH	6.54	6.52	6.39	6.24	6.5-8.5
Colour appearance	5	5	<5	5	
Real colour	5	<5	<5	<5	15.5
Turbidity	125	86	1.6	15	5
Dissolved solids	90	50	29	61	1000
Suspended materials	68	12	3	33	
Conductivity	11.6	8.4	3.8	8.6	
Chemical properties and nutrients					
Hardness	25	18	8	12	500
Alkalinity	21	20	11	5	
Nitrates (NO_3)	10.4	7.41	3.04	23.4	50
Nitrites (NO_2)	<0.05	0.07	<0.05	0.08	3
Calcium (Ca^{++})	5	4	<1	2	
Magnésium (Mg^{++})	2.8	1.8	1.5	1.6	
Phosphates (PO_4)	0.33	0.55	0.09	0.5	
Chloride	8.8	5	0.6	4.8	250
Sodium (Na)	4.7	3	1.6	4.4	200
Potassium (K)	7.8	6	2.1	5.4	
Sulfates (SO_4)	7	7	2	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002	0.002	(0.002 ; <0.002)	0.002	0.01
Sb (Total - dissolved)	(<0.003 ; <0.003)		(<0.003 ; <0.003)		0.005
Se (Total)	<0.00		<0.00		0.01
Hg (Total - dissolved)	(<0.001 ; <0.001)	<0.001	(<0.001 ; <0.001)	0.001	0.001
Fe (Total)	2.1	1.2	0.4	0.2	0.3
Mn (Total)	0.03	<0.02	<0.02	0.03	0.5
Cu (Total)	<0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.09	<0.05	0.09	<0.05	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.02	<0.01	0.01	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.00	<0.002	<0.00	<0.002	0.003
Al (Total)	4.15	7.14	0.19	0.74	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total Coliforms at 37°C/24h	Present	Present	Present	Present	0
Fecal Coliforms at 44°C/24h	Present	Present	Present	Present	0

Table 3.17 Results of analyzes of samples from Sissingue groundwater (Continued)

Properties	SSGW4		SSGW5		WHO Standards
	DS	WS	DS	WS	
Physical properties					
Temperature	29.3	29.3	30.4	30.1	
pH	7.29	7.22	6.41	6.51	6.5-
Colour appearance	<5	5	5	30	
Real colour	<5	<5	<5	<5	15.5
Turbidity	5	20	14	330	5
Dissolved solids	190	200	39	41	1000
Suspended materials	<1	4	67	405	
Conductivity	31	32.4	5.1	6	
Chemical properties and nutrients					
Hardness	109	111	9	16	500
Alkalinity	150	150	23	23	
Nitrates (NO_3)	0.11	<0.06	0.15	0.2	50
Nitrites (NO_2)	<0.05	<0.05	<0.05	0.05	3
Calcium (Ca^{++})	25	25	2	2	
Magnésium (Mg^{++})	11.5	11.8	1.4	2.5	
Phosphates (PO_4)	0.09	0.07	0.13	0.37	
Chloride	<0.1	0.7	<0.1	0.4	250
Sodium (Na)	23	21	3	3.6	200
Potassium (K)	2	2	1.6	2	
Sulfates (SO_4)	<1	<1	<1	<1	250
DCO	<25	<25	<25	61	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002)	0.002	(0.002 ; <0.002)	0.006	0.01
Sb (Total - dissolved)	(<0.003 ;		(<0.003 ; <0.003)		0.005
Se (Total)	<0.003		<0.003		0.01
Hg (Total - dissolved)	(<0.001	<0.001	(<0.001 ; <0.001)	<0.001	0.001
Fe (Total)	1	0.7	1.6	4.5	0.3
Mn (Total)	0.13	0.13	0.05	0.06	0.5
Cu (Total)	<0.02	<0.02	<0.02	0.03	1
Zn (Total)	0.14	<0.05	0.07	0.08	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.01	<0.01	0.02	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.002	<0.002	0.003
Al (Total)	0.2	<0.03	0.9	3.33	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total coliform at 37°C/24h	Absent	Absent	Absent	Absent	0
Fecal coliform at 44°C/24h	Absent	Absent	Absent	Absent	0

Table 3.18 Results of analyzes of samples from M'Basso groundwater (continued)

Properties	**SMGWW**		**SMGWW**		**WHO Standards**
	SS	SP	SS	SP	
Physical properties					
Temperature	29.4	29.2	29.5	29.4	
pH	6.75	6.18	7.18	6.3	6.5-
Colour appearance	5	5	<5	<5	
Real colour	<5	<5	<5	<5	15.5
Turbidity	35	12	11	20	5
Dissolved solids	50	27	148	29	1000
Suspended materials	30	11	<1	15	
Conductivity	6.8	4.7	22.2	4.8	
Chemical properties and nutrients					
Hardness	15	8	82	10	500
Alkalinity	19	8	98	10	
Nitrates (NO_3)	8.11	7.7	4.18	7.28	50
Nitrites (NO_2)	0.05	0.07	0.06	<0.05	3
Calcium (Ca^{++})	2	1	24	3	
Magnesium (Mg^{++})	2.4	1.1	5.2	0.6	
Phosphates (PO_4)	<0.02	<0.02	0.05	<0.02	
Chloride	1.2	1.2	0.5	0.7	250
Sodium (Na)	3.9	2.8	7.4	2	200
Potassium (K)	0.8	1.1	1.4	1.3	
Sulfates (SO_4)	2	<1	2	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002)	0.002	(0.002 ; <0.002)	0.1	0.01
Sb (Total - dissolved)	(<0.003 ;		(<0.003 ; <0.003)		0.005
Se (Total)	<0.003		<0.00		0.01
Hg (Total - dissolved)	(<0.001 ;	<0.001	(<0.001 ; <0.001)	<0.001	0.001
Fe (Total)	1.6	0.5	1.7	0.3	0.3
Mn (Total)	0.02	0.03	0.12	<0.02	0.5
Cu (Total)	<0.02	<0.02	<0.02	2.53	1
Zn (Total)	0.06	0.05	0.11	0.05	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.01	<0.01	0.02	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.00	<0.002	0.003
Al (Total)	2.1	1.66	0.58	1.11	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological properties					
Total coliforms at 37°C/24h	Present	Present	Present	Present	0
Fecal coliforms at 44°C/24h	Present	Present	Present	Present	0

Table 3.19 Results of analyzes of samples from Djoguenesso groundwater (continued)

	S	S	WHO		
Properties	DS	WS	DS	WS	
Physical properties					
Temperature	29.6	29.8	28.7	28.7	
pH	6.74	6.88	6.61	6.5	6.5-8.5
Colour appearance	5	<5	5	5	
Real colour	<5	<5	<5	<5	15.5
Turbidity	1.4	3.3	7.2	10	5
Dissolved solids	77	120	77	58	1000
Suspended materials	1	15	22	13	
Conductivity	11.8	19.6	10.7	7.7	
Chemical properties					
Hardness	35	72	28	17	500
Alkalinity	50	78	43	22	
Nitrates (NO_3)	0.73	3.49	2.59	5.64	50
Nitrites (NO_2)	<0.05	<0.05	<0.05	<0.05	3
Calcium (Ca^{++})	9	25	4	3	
Magnésium (Mg^{++})	3.2	2.4	4.2	2.2	
Phosphates (PO_4)	<0.02	0.03	<0.02	<0.02	
Chloride	<0.1	0.2	<0.1	1	250
Sodium (Na)	6.4	5.5	6.9	4.5	200
Potassium (K)	1	1.5	1	1.2	
Sulfates (SO_4)	1	1	<1	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total -	(0.002 ;	0.002	(0.002	0.002	0.01
Sb (Total -	(<0.003 ;		(<0.00		0.005
Se (Total)	<0.003		<0.003		0.01
Hg (Total -	(<0.001 ;	<0.001	(<0.00	<0.001	0.001
Fe (Total)	0.2	<0.1	0.8	0.1	0.3
Mn (Total)	0.02	<0.02	0.03	<0.02	0.5
Cu (Total)	<0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.08	<0.05	0.06	<0.05	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.01	<0.01	0.02	<0.01	0.05
Ni (Total)	<0.02	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.002	<0.002	0.003
Al (Total)	0.18	0.03	0.69	0.08	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oils and fats	<0.1		<0.1		
Microbiological					
Total coliforms at 37°C/24h	Present	Present	Presen	Present	0
Fecal coliforms at 44°C/24h	Present	Present	Presen	Present	0

Table 3.20 Results of analyzes of samples from Djoguenesso groundwater (continued)

Properties	STGW1 DS	STGW1 WS	STGW2 DS	STGW2 WS	WHO Standards
Physical properties					
Temperature	27.3	28.2	28.1	29.2	
pH	7.14	6.53	7.21	7.13	6.5-8.5
Colour appearance	5	<5	<5	<5	
Real colour	<5	<5	<5	<5	15.5
Turbidity	27	12	16	77	5
Dissolved solids	132	122	162	156	1000
Suspended materials	190	12	3	5	
Conductivity	17.1	16.4	21.2	23.3	
Chemical properties and nutrients					
Hardness	46	24	59	71	500
Alkalinity	68	14	98	105	
Nitrates (NO_3)	8.76	40.7	0.08	<0.06	50
Nitrites (NO_2)	<0.05	<0.05	<0.05	<0.05	3
Calcium (Ca^{++})	6	5	9	12	
Magnésium (Mg^{++})	7.8	2.9	8.7	10.2	
Phosphates (PO_4)		0.03		0.26	
Chloride	1.3	11.6	<0.1	0.2	250
Sodium (Na)	17	9.9	19	20	200
Potassium (K)	2.2	6.3	2.6	2.6	
Sulfates (SO_4)	1	<1	1	<1	250
DCO	<25	<25	<25	<25	
DBO_5	<5		<5		
Heavy metals					
As (Total - dissolved)	(0.002 ; <0.002)	0.002	(0.002 ; <0.002)	0.002	0.01
Sb (Total - dissolved)	(<0.003 ;		(<0.003 ; <0.003)		0.005
Se (Total)	<0.003		<0.00		0.01
Hg (Total - dissolved)	(<0.001 ;	<0.001	(<0.001 ; <0.001)	<0.001	0.001
Fe (Total)	8.2	0.1	4.1	0.7	0.3
Mn (Total)	0.16	<0.02	0.06	0.05	0.5
Cu (Total)	0.02	<0.02	<0.02	<0.02	1
Zn (Total)	0.13	0.06	0.08	0.06	3
Pb (Total)	<0.01	<0.01	<0.01	<0.01	0.01
Cr (Total)	0.03	<0.01	0.01	<0.01	0.05
Ni (Total)	0.03	<0.02	<0.02	<0.02	0.02
Cd (Total)	<0.002	<0.002	<0.00	<0.002	0.003
Al (Total)	0.98	0.45	<0.03	<0.03	0.2
Mo (Total)	<0.05	<0.05	<0.05	<0.05	
Co (Total)	<0.05	<0.05	<0.05	<0.05	
Oil and fat	<0.1		<0.1		
Microbiological properties					
Total coliforms at 37°C/24h		Present	Absent	Present	0
Fecal coliforms at 44°C/24h		Present	Absent	Present	0

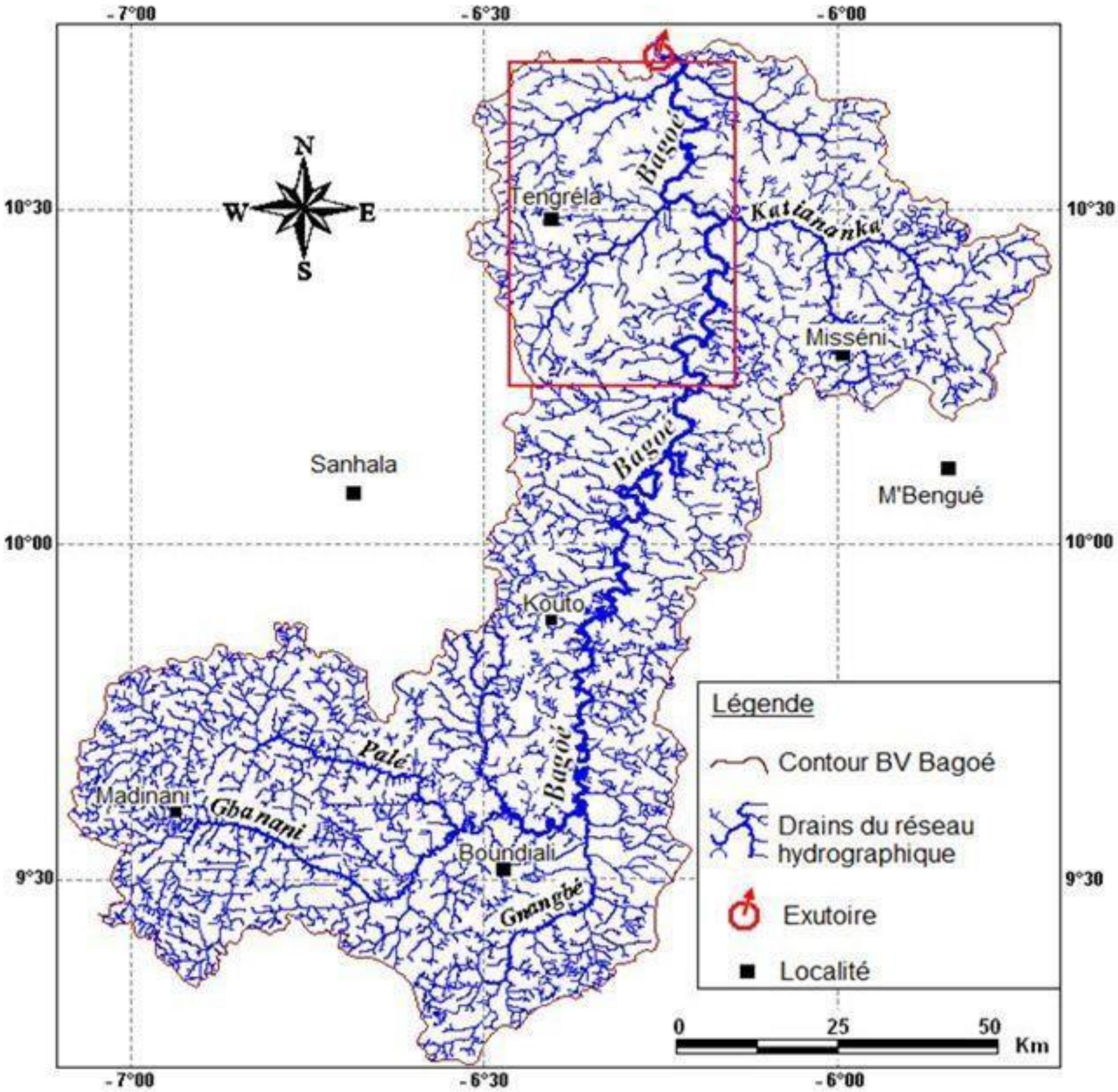
NB : the concentrations are expressed in mg / l with the exception of pH, color (platinum / cobalt), temperature (° C), turbidity (NTU) and of the conductivity (mS / m), hardness (mg / l CaCO3), alkalinity (mg / l CaCO3), WHO drinking water standards (DS: dry season; WS: wet Season).

3.3 AQUATIC ENVIRONMENT

3.3.1 Hydrology

The study of the flow characteristics of the Bagoé river was conducted from hydrometric stations Kouto and Papara.

The drainage system of the Bagoé river has seven orders according to the Strähler classification. The most important is the Bagoé river. Its main tributaries: the Gbanani the Pale, the Sougoumon the Gnangbé and Katiananka are of order 6 and 5 (Map 2).



Map 2 River network of the Bagoé Basin

3.3.1.1 Stream flow rates

Analysis of the flow gauging stations of the area shows a single peak in September.

The average annual flow of the Bagoé to Papara is 33.11 m3 / s with a specific rate of 0.0037 m3 / s / km2. At Kouto, the annual average flow of 42.76 m3 / s with a specific flow rate 0.009 m3 / s / km2..

3.3.1.2 Location of hydraulic structures

The Bagoé River has several hydraulic structures that facilitate the flow of surface water. In addition, there are two agro-pastoral dams (Pourou, Kanakono) in the project area.

The Map 3 presents the situation of hydraulic structures on the surface water.

Map 3 Situation of hydraulic structures on surface water

3.3.1.3 Use of surface water

The main uses are domestic and semi industrial by artisanal miners.

The project area has many sacred water issues related to religions practiced by the people of the region. However, outside the dry season surface water is commonly consumed by those not aware of the risks of waterborne diseases.

3.3.2 Hydrogeology

3.3.2.1 Geological setting

Granite formations occupy most of the area. Geological formations in the project area date back to the lower Proterozoic period. They are derived from Eburnean granitisation and basic plutonism.

The familiar weathering profile obtained is the result of long and complex external geodynamic processes:

- a thin layer of humus surface soil that serves as support to the plants;
- regolith clay.

These granite formations are very poor aquifers because the hydraulic conductivity (permeability) is very low. These formations, however, play an important role in the underlying nutrient draining fractures. The different rocks are predominantly red lateritic clays and laterite breastplates, grainy granitic arenas, multifissured transitional zone and bedrock.

3.3.2.2 Study from the works of the project area

There are two agro-pastoral dams including one located at Pourou which contains water at a very low level and the other at Kanakono that is completely dry.

Moreover, many hydraulic structures pass through the main tributaries of the Bagoé river. A new larger culvert is being built on a tributary of the Bagoé to Danzourou. Traditional wells, modern wells and boreholes represent groundwater catchment with regolith or base fractures resources.

However, the war situation that prevailed in Côte d'Ivoire since 2002 has led to non-maintenance of works of the area of interest.

All requirements in the area are not met. Recently some villages have benefited from a post-crisis funding that took place in the area and were able to obtain new wells.

3.3.3 Water supply sources

In this part of the Ivory Coast, the two main populations' power sources are groundwater and surface water. Well water is used in the project area for the laundry, dishes, watering and to a lesser extent the drilling during the defection period or when this is the only point of supply.

Some villagers in the study area almost exclusively use the traditional wells and temporary sumps shallows to avoid participating in maintenance costs of modern works.

3.3.4 Hydrobiological study

The sampling work was carried out during the dry season from 22 April to 05 May 2010 and in the wet season from 31 July to 12 August 2010. The study focused on the aquatic populations of fish; phytoplankton and benthic invertebrates. The physical chemical properties (pH, conductivity, dissolved oxygen, temperature, total dissolved solids, transparency) were measured in situ in each sample site (Map 4).

Map 4 Location of the sites (BA1 to BA13) in the Bagoé basin

3.3.4.1 Phytoplankton

In total 60 phytoplankton species were identified (45 species in the dry season and 30 during the wet season). The Conjugatophyceae class is best represented with 23 species. The least represented class is the Dinophyceae with one species.

Stations that have higher species richness are B6 and B8 each with 24 species. Sixteen(16) species were collected only during the wet season while 29 species in the dry season samples are missing from wet season samples.

Only four species of phytoplankton in the inventoried Bagoue river are associated with eutrophic conditions. Those are :

- Pandorina morum
- Pediastrum duplex
- Eudorina elegans et
- Navicula cuspidate

This is an indication that the sampled environment is not polluted.

Transparency and temperature are abiotic properties that would influence more diversity of phytoplankton.

The structure and development of phytoplankton are also influenced by inputs of nutrients due to urban and agricultural waste, which are an indirect cause of the rich phytoplankton of some rivers.

3.3.4.2 Zooplankton

The zooplankton obtained consists of 12 compound species of three (3) copepods:

- Thermocyclops decipiens
- Thermocyclops sp.
- Mesocyclops sp.

and nauplii and six cladocerans:

- Diaphanosoma excisum
- Ceriodaphnia cornuta
- Moina micrura
- Moinodaphnia sp.
- Alona sp.1
- *Alona* sp.2, ostracods and chironomid larvae,

Six (6) speices were sampled in the wet season:

- Thermocyclops decipiens
- Mesocyclops sp.

- Ceriodaphnia cornuta
- Alona sp.1
- Alona sp.2
- Larves de chironomidae

While five (5) species were inventoried during the dry season:

- Thermocyclops sp
- Nauplii
- Moina micrura
- Moinodaphnia
- ostracods

Only Diaphanosoma excisum was harvested during the two sampling periods.

3.3.4.3 Benthic fauna

During both periods, 6 benthic organisms in three taxonomic groups (insects, Millipedes and worms) were identified in the sampled stations. Insects include 3 Culicidae larvae (each represented by one individual) and Chironomidae (n = 3). A centipede and an oligochaete represent the Myriapods and worms. Only the Chironomidae was collected during the wet season, other species were sampled in the dry season. The low diversity of this fauna could be explained by the sandy substrate of Bagoue river, which is incompatible to the development of these organisms due to its high porosity.

3.3.4.4 Ichtyologique fauna

A total of 57 fish species distributed in 17 families and 37 classifications were identified. Families that have the highest specific diversity are those of the Mormyridae and Mochokidae with 11 and 10 species respectively. They are followed by those of Cichlidae (n = 7), Cyprinidae and Alestidae each with 5 species. Other families include between 1 and 3 species. There is a more or less significant influence of the season on the ichtyologique Bagoé settlement, 11 species complete the list of species sampled in the dry season. This is among other Brienomyrus Niger, Hippopotamyrus psittacus, Mormyrops anguilloides, Petrocephalus Bane, Alestes baremoze, Heterobranchus longifilis, budgetti Synodontis, Synodontis catfish, Synodontis sorex, Hemichromis bimaculatus and Tilapia guineensis. In addition, 20 species found in the dry season were not sampled in the wet season. The number of Mormyridae harvested fish species (n = 11) during the present investigation indicates better quality of studied aquatic environments.

All these data suggest that the aquatic environment of the Bagoé remained, so far, quite well preserved.

Quantitative analysis showed that 1008 fish individuals with a total mass of 23045.49 g were collected during this study. In the dry season, 548 individuals of 46 species were recorded. This population is numerically dominated by Brycinus leuciscus (n = 63), Brycinus nurse (n = 62), Petrocephalus Bane (n = 58) and Schilbe intermedius (n = 51). In the same season a total mass of 9897.49g was recorded. Species Brycinus nurse (n = 1408g) Brycinus macrolepidotus (n = 1048g), Synodontis shawl (n = 788) and Tilapia zilli (n = 506) were the most important. The B8 station

(Kanakono) is the richest station in individual species (n = 251) and the largest in terms of weight (p = 4360g).

During the wet season, 460 individuals with a total mass of 13148g were sampled. The species Petrocephalus Bane (n = 65), Hippopotamyrus psittacus (n = 63), Brycinus nurse (n = 46) and Schilbe mandibularis (n = 42) are the most important. Relative to their weight, the Marcusenius senegalensis (n = 2554g) Hippopotamyrus psittacus, Brycinus nurse (n = 1160), Petrocephalus Bane (n = 1017g) and Schilbe mandibularis (n = 1052g) species dominate the population. BA1 Sissingue station is the richest in number (n = 170) with the number and weight (p = 5132g).

3.4 DESCRIPTION OF THE LANDSCAPE

3.4.1 Methodology

The landscape survey was conducted from photographs and visual observations. These views have helped to highlight the organization and articulation of spaces, scenic highlights and perception of the site. The sites of particular cultural or religious interest were identified during the socioeconomic study. These are sacred sites for local people.

The study was based predominantly on field observations (pictures, surveys of flora and fauna and land use study) and information gathered from various administrations and local populations.

3.4.2 Soil Environment

Soil genesis depends on several factors including regional climate, topography, parent material and type of vegetation.

The soil survey included the mining perimeter and surrounding area (250 m on either side of the axis), as well as the two access roads from Tengrela. The terrain has little contrast.

The network of natural drains is very loose; it consists of several tributaries of the Bagoue River, which borders the perimeter in its northern part, and along which is a flood plain, which is relatively wide in some areas. The natural vegetation is the savannah, with very sparse woods.

3.4.3 Landscape

The main landscape units encountered in the study area are divided into three (3) large groups following the topographical sequence of the environment. They include medium slopes formed by hills and slopes, gentle slopes formed by peaks and flood zones. The hydrographic network consists of Bagoé tributaries that are dry outside the wet season.

3.4.4 Slopes

The slopes are formed by some hills and gradients. These landscape units are located in the eastern part of the village of Sissingue and the northeastern part of the project area. This environment is usually grown on the hills and slopes.

3.4.5 Low slopes

Low slopes correspond to peaks that are located in the central and northern project area.

The peaks are represented by laterite outcrops and summits often covered with old fallow grasses or odorata, the result of an old farm. The vegetation present is considered a sparse shrub savanna with some wooded and large grassy areas.

3.4.6 Flood zones

Theses areas are mainly found in the southern part of the project area, and along the Bagoé river, which forms the natural border with Mali.

3.5 ECOLOGICAL ENVIRONMENT

3.5.1 Study of the flora

The botanical aspects of Sissingue gold project has been made by the National Centre for Flora of the University of Cocody-Abidjan, Ivory Coast. The sampling was carried out during the periods from 22 April to 1 May 2010, from 12 to 21 July 2010, and from 29 January to 7 February 2011.

The objective of this work is to achieve a descriptive study of vegetation and the different existing ecosystems on the project site and their floristic composition, specifically the identification of existing flora, and all particulars relating to the zone, including the presence of rare species, endangered species or endemic species.

For the floristic inventory, two survey techniques were used namely, the surface survey and itinerant statement. For surface surveys, 54 plots were established. Roaming surveys conducted along transects, tracks and in some very inaccessible places, from one plot to another around the plots, helped complete the general floristic list of the site after surface surveys (Map 5).

Map 5 Platelet distribution and points of itinerant floristic inventories

3.5.1.1 Key formations in the project area

Nine (9) major habitats have been identified on the project site including:

1. woodlands
2. gallery forests
3. wooded grassland
4. shrublands
5. woodland
6. grassland
7. ponds
8. lakes
9. fallow and crops

3.5.1.2 Floral composition of the project area

The study of flora identified 417 plant species belonging to 269 genera and 84 families.

The most represented genres are: Ficus (12 species), Combretum (9 species), and Hyparrhenia Panicum (6 species each). The most diverse families are those of the Poaceae (62 species), Fabaceae (32 species), Euphorbiaceae (28) Caesalpiniaceae (20) species), Combretaceae and Rubiaceae (17 species each). The most predominant species of the site are:

- Baissea multiflora (29 identified)
- Lannea acida
- Parkia biglobosa with 24 identified each

Among the predominant species (frequencies of occurrence in the plots above 12), only 3 are creepers. Among the species identified, eleven (11) are typical of the forest and 65 are strictly Sudanese savannah.

The diversity index indicates shrublands (4.76) and woodland (4.72) are more diversified than other vegetation types (**Table 3.21**). The grassland is less diversified.

Regarding the equitability index, it approaches 1 (0.92 to 0.99) for all vegetation, which states that all species found on the gold site have nearly the same abundance. It can be deduced that the environment is floristically balanced.

Table 3.21 Shannon diversity index and Pielou Equity of 8 major vegetation types encountered on the project website

Types of vegetation	Shannon and Weaver Index (H)	Piélou Equity (E)
Woodland	4.72	0.95
Gallery forest	4.45	0.97
Fallow	4.42	0.98
Savannah	4.13	0.98
Shrubby savannah	4.76	0.92
Woodland	3.29	0.99
Pond	3.66	0.99
Grassland	2.98	0.99
Project area	**5.36**	**0.91**

3.5.1.3 Endemic and endangered species

Among the species recorded, two (2) were reported as West African endemic species. These are Anthostema senegalense (Plot 4) and Moghania faginea (Parcels 2 and 13) according to the lists of Ake-Assi (2001; 2002).

The inventoried flora of the Sissingue site is relatively poor in endemic species.

In addition, the study identified three species (**Table 3.22**), that are considered rare and endangered (Map 3.6) according to the IUCN Red List (IUCN, 2008).

Table 3.22 Rare and endangered species according to the IUCN (2008).

N°	Plant species	Family	Threat category	Plot N°
1	*Khaya*	Meliaceae	VU A1cd ver 2.3 (1994)	33, 43, 45
2	*Pterocarpu s*	FaBaceae	LR/lc ver 2.3 (1994)	4, 11, 31, 43
3	*Vitellaria paradoxa*	Sapotaceae	VU A1cd ver 2.3 (1994)	12, 14, 16, 17, 19, 20, 24, 29, 32,

Six (6) species **(Table 3.23**) are considered endangered according to AKE - ASSI lists (1998).

Table 3.23 Rare and endangered species according to AKE ASSI (1998)

N°	Plant species	Family	Plot N°
1	*Detarium microcarpum*	Caesalpiniaceae	2, 10, 12, 13, 17, 25, 26, 27, 30,
2	*Lannea nigritana*	Anacardiaceae	Itinerant
3	*Nauclea xanthoxylon*	Rubiaceae	Itinerant
4	*Syzygium guineense* var. *guineense*	Myrtaceae	4, 11, 24, 25, 31, 39
5	*Syzygium guineense* var. *macrocarpum*	Myrtaceae	31, 39
6	*Uvaria tortilis*	Annonaceae	6

Some parts of the forest in the study area are important for the conservation of species.

Many uses are associated with the plants collected on the project site. There are medicinal plants and food crops. Therapeutically, the population of the project site largely depends on the local traditional medicine. A total of 57 species have been identified for use in the preparation of traditional medicines. In addition, 23 species were counted that are used as food crops.

Error! Reference source not found. and Map 6respectively show the location of rare and endangered species according to IUCN (2008) and AKE-ASSI (1998).

Map 3.6 Location of rare species and endangered according to the IUCN (2008)

Map 6 Location of rare species and endangered according AKE-ASSI (1998)

3.5.2 Fauna Study

Fauna sampling took place from 24 April to 2 May 2010 (end of the dry season), 12 to 19 July 2010 (wet season) and from 29 January to 7 February 2011 (early dry season). The main objectives were to:

- assess the biological diversity of wildlife relevant to the study area;
- list the existing species;
- identify rare, endemic and endangered species,;
- determine, if possible, migration of key species.

3.5.2.1 Study methodology

The qualitative and semi-quantitative information was collected through direct and indirect observations in the field of ethnozoological surveys based on interviews with local people and bibliographic data.

Sample Sites

The first phase of the study retains land use as the main criterion for selection of sites to be sampled. Based on this selection criterion, four major habitat types (savannas, crops and fallow areas, water bodies and their surroundings and forests) were identified and sampled.

For sampling of large mammals, ethnozoological surveys were conducted among populations. The use of Kingdon guides (1997, 2004) to ensure the description of the animals was the primary means of interview with the population.

Moreover, the method of site transects was used to inventory large wildlife (Pollock, 1978; Burnham et al. 1980; Seber, 1986; Poilecot et al 1991;. & Schwarz Arnason, 1996; Sutherland, 1996 ; Williams et al 2002). Seventeen transects with a total length of 48.1 km were established to explore key habitats (Map 7).

Several methods were used to inventory small mammals:

- Yrapping
- Digging on surfaces of 100 m2
- The collection of specimens from children

In addition, summary investigations have confirmed the presence of species suspected or reported in the literature and not collected in this study.

With respect to birds, the main method used in this study consisted of bird watching by walking slowly along the tracks and existing transects in different habitats. Notes were taken from visual observations, vocalizations and bird habitats.

Map 7 Layout of transects in the study area

3.5.2.2 Study Results

Mammals

Large wildlife is not very diverse at the study site.

At the beginning of the dry season, 87 animals were observed representing 16 animal species. Bushbuck is the dominant species (seen 33 times) compared with seven times for the genet, which is the second most observed species. The cane rat, patas and porcupines were seen six times each; civet, hares and rabbits five times. The least common species are the sidestripe jackals, white-tailed mongoose, black duikers, giant squirrels and gophers. The aardvark, seen twice, is one endangered species in the region.

In addition, 10 species were sampled at different frequencies in the late dry season and wet season (**Table 3.24**).

Table 3.24 Observation frequency of the main species of mammals

Mammals	Frequency of observation (KAI)	Frequency of observation	
		End of dry	Rainy season
Black duiker	0.14	3	3
Giant stanger squirrel	0.05	1	2
Bushbuck	0.14	3	10
Genet	0.05	1	2
Gambia Helioscure	0.1	2	1
Hare	0.05	1	3
White-tailed mongoose	0.05	1	5
Patas	0.09	2	2
Rat	0.14	3	4
Palm Rat	0.18	4	3

At the end of the dry season, the cane rat was most frequently observed with a kilometric index of abundance (IKA) of 0.18. Then came the rat, bushbuck and black duiker with IKA 0.14. The giant squirrel, genet, hare and the white-tailed mongoose have only been observed once each. The Gambia héliosciure and the patas are very common but were only observed twice during the study.

At the beginning and end of the dry season, the largest number of observations took place in bushland with the respective proportions of 58.6% and 42.9%.

During the wet season, the bushbuck was observed most frequently (10 times). This was followed by the white-tailed mongoose, which is the second most common species to be observed (5 times). Other species have varying frequencies of observation.

The largest number of observations of mammals occurred in bushland beginning of the dry season (58.6%), in the late dry season (42.9%) and in the wet season (34.3%).

Transects D1D2 and P1P2, are respectively located along a tributary of the Bagoue and along the Bagoue itself, with the greatest number of observations at beginning of the dry season.

Moreover, the transect Mab1 located in the forest along the Bagoé had the largest number of animals in the late dry season and wet season. However, the frequency of observaton is higher for the majority of animals in the wet season.

There are 18 individual mammals in 3 species (Praomys rostratus, Dasymys incomptusn, Tatera valida), 3 genres (Praomys, Dasymys) and 2 families (Muridae, Gerbillidae) (**Table 3.25**).

Table 3.25 List of mammals captured during trapping and digs

Family	Genre	Species	Method of capture	Habitat
Muridae	Praomys	P. rostratus	Trapping	Gallery forest
	Dasymys	D. incomptus	Digging	Wooded savannah
Gerbillidae	Tatera	T. valida	Chauvancy	Savannah
Total	3	3	3	

One species (Praomys rostratus) was captured in the forest compared to two (Dasymys incomptus and Tatera valida) in the savannah. The species Praomys rostratus (n = 10) is the only representative of forest mammals in the study area. Micromammals in open environments are represented by two species (Tatera valida, n = 7; Dasymys incomptus, n = 1). Other mammals such as the African straw Dogfish (Eidolon helvum) and Herison Atelerix albiventris were observed.

Birds

In the sampled habitats during the dry season there was a total of 139 bird species identified- 139 at the beginning of the dry season and 121 at the end of the dry season. These 139 species are divided into 51 families. There were more individual birds obtained early in the season (5115 individuals) than in the late dry season (4031 individuals).

In the wet season, there were 2169 individual birds divided into 114 species and 50 families. In terms of individuals, the population of birds obtained in the dry season is far greater than that obtained in the wet season.

Seventeen of these 139 species (sixteen resident in Ivory Coast and one intra-African species) which were not observed in the first study phase (dry season), were identified in the second phase (wet season). Also, it was noted that 24 species of birds observed in the dry season were not inventoried in the wet season. In addition to three species endemic to West Africa (the parrot Poicephalus senegalus dinghy, the Turaco purple Musophaga violacea and Gonolek Barbary Laniarus Barbatus) inventoried in the dry season, the Waxbill Estrilda caerulescens vinegar tail was observed in the study area.

14 of the 39 or 35.90% of the bird species were found in the Guinea Sudano savannah in both seasons. The migratory categories of species (intra-African and Palearctic) are higher in dry season than wet season. In different habitats, it should be noted that the numbers of species and individuals are higher in dry season than wet season.

With 139 species, or 18.39% of the bird species recorded in Ivory Coast, the Sissingue area deserves special attention, although the area lacks any bird species whose protection is of global concern (IUCN, 2008). Furthermore, it should be noted that 75% of 24 species not observed in the wet season, are migratory species. Indeed, it has been shown that the majority of migratory birds arrive in the Ivory Coast during the dry season and leave early in the wet season (Thiollay 1985).

Other land animals such as insects, amphibians and reptiles were observed. Some amphibians of the genus Bufo were seen near the river and some reservoirs present in the dry season. In the wet season other types of amphibians have been identified in the vicinity of temporary dams: Phryno Batracus and Hyperolius. The most frequently observed reptiles are represented by the lizard Nile Varanus niloticus L. 1766, with several specimens observed along the Bagoue river. Some common snakes in the northern area of the Ivory Coast including the Seba python (Python sebae Gmelin, 1789 listed on the IUCN Red List) were observed by the guides.

3.6 AETIOLOGY, LAND USE AND AGRICULTURE

3.6.1 Soil Study

The soil study is designed primarily to chemical morphological characterization of soils in order to:

- appreciate their intrinsic quality and agricultural vocations,
- assess the likely impact of gold mining on soil development and production capacity;
- propose protective measures or mining operation after stabilization..

3.6.1.1 Study Methodology

A literature review was conducted to enumerate the geomorphological context of the Tengrela region. On the mining perimeter a systematic grid method, valid for large-scale works, and set to the density of observation 0.5 / cm2 of the map was adopted (FAO, 1987).

3.6.1.2 Descriptive traits

- Environment (Position on the half-interfluve, Vegetation cover, soil surface state);
- soil (depth, primary color, color, proportion and nature spots, proportion, size and nature of the coarse elements, organic matter, texture, structure, porosity, consistency, indicators of wildlife activity, proportion, direction, size and distribution of roots);
- Analytical determinations: The analysis methods used are those proposed by Pansu and Gautheryou (2003). They determine the particle size, pH, organic carbon, total nitrogen, mineralizable Nitrogen, total phosphorus and Exchange complex;
- soil and soil mapping classification: soil classification method adopted matches the CAM system, BRM release;
- Factors of Soil Capability: the FAO (1976) method, which monitors the main physical characteristics, chemical and biological soil.

3.6.1.3 Soil environment

The soil survey concerned the mining perimeter and the two access roads (250 m on either side of the axis) from Tengrela.

3.6.1.4 Description of soil

The description of the observation points, including 22 soil pits with a maximum depth of 125 cm, geologists trenches and drilling surveys, revealed the existence of the perimeter of three secondary process of the evolution of soils (induration, redesign, waterlogging).

3.6.1.5 Results

The soil of the project area is dominated by ferralithic soil, desaturated soils and waterlogged areas (Map 8)

Map 8 Soil map

Soil formation is characterized by two evolutionary processes at the Tengrela mine perimeter: redesign and induration. They affect the upper part of the majority of soil exposed areas. Hydromorphism is a consequence.

In effect, the redesign and induration led to a slowdown in the vertical dynamics of the water, in light of the flatness of the topography. The consequences of these processes agriculturally are quite strong and are reflected primarily through low installation depth, especially an accentuation of mechanical erosion as a result of tillage (silt is more dominant in the grain size) (

Table 3.26).

Chemical fertility, is mainly limited by low amounts of phosphorus pentoxide, and the low availability of nitrogen at the end of the fallow period.

Table 3.26 Soil texture

Soil unit	Coordinates	Clay	Fine Silt	Coarse silt	Fine sane	Coarse sand
Redesigned Indurated	1154507/807976	19.4	10.8	16.5	25.9	26.6
	115617/788969	07.2	03.2	11.6	33.5	30.0
Typical redesigned	1155067/804912	13.1	15.2	21.4	20.6	28.5
	1156442/804471	15.7	13.3	26.0	22.7	22.1
Hydromorphy	1148261/806321	18.8	20.7	22.2	18.6	18.3
	1149955/807570	12.8	24.1	21.9	21.6	19.4
Garden zone	1156442/804471	15.7	13.3	26.0	22.7	22.0
Savannah	1150784/803494	46.8	19.6	15.0	10.4	8.0

3.6.2 Land and agriculture

The study of land use includes an agricultural census on the entire perimeter of the project area and the access roads, with a total of 466.82 km². This study gathered information obtained from traditional authorities, populations encountered during various exploration missions, and several departmental technical services namely the Agriculture and Animal Resources Services.

Collecting field data has led to detailed information about agronomic practices and farm returns in the project area. Finally, a map of land use was established based on the results of the agrarian census (Map 9).

Map 9 Land use

3.6.2.1 Different types of land use

The mining perimeter covers an area of 44,600 hectares. In total 1219 farms exist on the mining perimeter. These farms cover a total area of 4895.18 hectares or 10.98% of the area.

The rest of the area is covered by fallow, bushland, wooded grassland. Bushland dominates the project area.

The savannah, estimated to be about 3649 hectares of the mining perimeter, is under strong pressure from farmers who engage in slash and burn for the installation of plantations.

Moreover, some small areas of forest (448.56 hectares) remain in the perimeter.

3.6.2.2 Description of the farming system

The farming system uses manual labour and carts pulled by oxen. What is left over from the original natural vegetation is burned.

During the wet season, food crops (maize, sorghum, peanuts, etc.) and various vegetable crops (peppers, okra, eggplant, etc.). are sown in the goal of helping to cover the food needs of the family.

3.6.2.3 Indicators of the suitability of soil cultivation

In Sissingue the survey conducted showed that for the majority of farmers, land located near wetlands (Bagoé river and its tributaries) is the best place to farm.

Regarding crops, soil quality has very little involvement in the decision-making, the extent of available resources matters most. In all cases, the assessment of the quality of soil is done retrospectively, from the production obtained.

3.6.2.4 Spatial configuration

The area is immobilised over time and due to the increase in growing perennial crops, food crops are assigned to more marginal land, sometimes outside the family’s field.

3.6.2.5 Agrarian landscape in the project area

Distribution of farmers according to their origin

There are 778 people with a farm on the mining perimeter and all the farmers who operate a parcel on mining perimeter are from villages and camps present in this space. Operators are predominantly from Kanakono (42.54%), Papara (13.88%) and Sissingue (13.11%). The peasant population that lives permanently in the encampments consists essentially of Fulani whose main activity is livestock.

The total area of the farms on the mining perimeter is 4895.18 hectares.The areas of food crops account for over 80% of cultivated areas. 1963.15 hectares or 40.15% of the total cultivated area is food crops (single species or in combination with each other) are the most important. This shows the importance of the land in terms of of food self-sufficiency of people in the area.

Cashews make up 1504.58 hectares of sole crops, or 30.77% of the total area. Also cashews are associated with food crops that cover 718.12 hectares or 14.68% of the total cultivated area. In the region, cashews provide regular financial income to farmers and provides a fence for protection of rural area property.

Among cereals, maize is the most farmed with 16.45% of the area, representing 804.44 hectares. Furthermore, the study revealed the existence of a palm grove covering 4.12 hectares. As for cotton, it covers approximately 10.77% of the cultivated area, or 527.02 hectares.

NB: All these data could undergo change because the study was conducted at the beginning of the period of land development. This explains the absence of certain food crops and the notion of "newly cleared space" in the presentation of results.

Access roads

In order to make a choice between the two access roads to the mine site, the ratings of both sides of these two routes led to the exploration of an area of:

- 10.22 sq km for Tengrela Kanakono-axis (route 1)
- 10.60 sq km for Tengrela- Sissingue axis (route 2).

It appears from this investigation that access to the mining perimeter by Kanakono could cause more damage to habitat than to farms (**Table 3.27**).

Table 3.27 Comparison of the two access roads

Characteristics	**Route 1**	**Route**
Impact area (Km^2)	10.22	10.60
Villages	3	2
Number of farms	85	82
Acreage (hectare)	419.5	265.3

3.6.2.6 Inhabited areas

The habitat consists of villages and camp on the site. This includes Kanakono, Sissingue, Kramosso, Gbini 1 Gbini 2 Zanikan, Ziékoundougou, Tionguoli, Papara Basso and Doubasso. There are also several settlements in the study area. The total habitat covers 749.76 hectares, or about 1.68% of the area.

3.6.2.7 Analysis and synthesis of the land use system

At the end of the study, it appears that about 10% of the mining perimeter is covered by agricultural activities. Perennial crops, including cashew and natural species such as locust bean and shea occupy an important place in these activites. These crops will require special attention in conducting mining activities.

Pure and intercropping cultures are the two culture systems used. Pure cultures were observed in the field through adults cashew plantations. Also, the observation of some fallow has shown that monoculture is also practiced with annual or food crops.

In addition, access to mining perimeter by the Tengrela-Sissingue route appears to have less effect on the environment compared to the Tengrela-Kanakono route.

3.7 HUMAN ENVIRONNEMENT

3.7.1 Socio-economic study

3.7.1.1 Tengrela

Tengrela is located in the north of Ivory Coast. It is bounded to the north, east and west by the Republic of Mali; to the south by Kouto; south-east by Korhogo and in the southwest by Odienne.

Tengrela covers an area of 2200 km2. It consists of three sub-prefectures (Tengrela, Kanakono, Débété), 6 towns including 4 rural communes, 49 towns and 195 settlements. According to data of the General Census of Population and Housing (RGPH) of 1998, the population is estimated at 63 644 inhabitants. The main economic activities in Tengrela are agriculture and livestock. It is the main activity practiced by the population (75.42% of the total population).

There are three major types of agricultural production systems:

- anual production for market gardening and food crops such as millet, sorghum and rice;
- Production with the horse; usually for cotton, corn and peanuts;
- motorized production, mainly with tractors in growing cotton, corn and peanuts.

Livestock: concerns mainly cattle (16 805 animals for 675 herders), sheep (4815 heads for 666 breeders), pigs (3446 372 heads for owners) and poultry (Traditional practice).

3.7.1.2 Economic, social and cultural infrastructure

Roads: the main roads in Tengrela are unpaved. The main roads that connect to neighboring departments are the Tengrela-Boundiali road (120 km), the Tengrela M'bengué-Korhogo road (160 km), the Tengrela-Gulya-Odienne road (200 km).

Telecommunications: Telecommunication services are provided by the Côte d'Ivoire Telecom company and mobile phone operators (Orange, MTN, Moov, Koz). Radio and national television emission are received regularly in the departments. Mail delivery is not assured in Tengrela since September 2002.

Water supply and electricity: Société de Distribution d'Eau de Cote d'Ivoire (SODECI) and the Ivorian Electricity Company (CIE) supply the department with water and electricity respectively. In the department, only 6 localities have electricity.

Markets: The department includes five markets covered in 5 locations. The city of Tengrela is located on the border with Mali, its market is of national and even sub-regional interest.

Education: The education service at the Tengrela department is organized around primary and general secondary education. At the level of primary education, the department has inspected (IEP) including forty six (46) establishments, thirty six (36) of which are functional. Ten non-functional facilities lack teaching staff. There is a secondary and technical education institution.

The exploitation of natural resources mainly involves fishing. Fishing is done in the traditional way on the rivers of the Bagoue and Mahandianabani. The exploitation of fishery products from these streams, due to their geographical position, is made by the people of Malian communities and Tengrela localities. To a lesser extent, fishing is done on lakes of some agricultural dams in the Department (Lomara, Néguépié).

3.7.1.3 Methodology and selection of the project area

The villages M'Basso, Danzourou, Djoguénesso, Kanakono, Kotou, Pourou, Sissingue, Tialaka, Gbini 1 Gbini 2, Katara, Tiongoly, Zanikan, Ziékoundougou, Papara Doubasso and Basso, and settlements and hamlets attached to them have socio-economic interest to the project (Map 10).

Map 10 Localities studied in the project

In this study, information sources were diverse. Thus, people belonging to different social groups, categories and religious institutions have been consulted. These are:

- modern authorities (Secretary General Prefecture, Sub-prefects, local representatives, etc.);
- institutional managers (technical service responsible: agriculture, mining, ANADER);
- religious leaders;
- traditional authorities;
- managers of foreign communities (immigrants and non-indigenous);
- school officials and health facilities;
- rural organizations (cooperatives, farmer groups);
- farmers;
- women's organizations;
- youth organizations;
- miners;
- landowners;
- heads of households.

The choice of the sample of respondents was guided by the desire to gather facts from all parties involved in the study. Regarding the size of the sample, it was determined according to the type of contact involved.

Regarding data collection techniques, apart from the literature, two instruments were used: interviews and observation. Ultimately, it is a participatory process that allowed us to inform various social groups and prepare them to provide the information sought.

A total sample of more than 500 people has been consulted and is split as follows:

  - Prefect : 01 ;
  - Prefecture secretaries : 01
  - sub-prefects : 02

- local officials and traditional authorities in the region :
  - General councillors : 03
  - Local councillors : 01
  - Traditional authorities : 179
  - Religious authorities: 05
  - Indigenous leaders : 16
  - Foreign leaders : 05

- Leaders of youth organisations : 15
- Leaders of women's organisations : 17

- Technical administration officials
  - Mining and energy: 01
  - Health : 03
  - Primary education : 05
  - Technical education : 01
  - Secondary education : 02
  - Agence Nationale d'Appui au Développement Rural (ANADER) : 05
- Grassroots
  - Executives of villages involved : 05
  - Heads of households : 113
  - Landowners : 32
  - Farmers : 361
  - Gold washers : 17
  - Students : 05

3.7.1.4 Use of the project site

The project area, from the perspective of its land resources, is subject to a right of unilateral use. The Senufo people are the first people of the land. In terms of their legal status the land belongs officially, to the rural area where all socio-economic activities are authorized by the State of Ivory Coast. As such, the land belongs to the village and villagers. The lineage of the founding ancestor (the koulofolo) is represented by its leader, the chief. The demand for land for agricultural activities is typically accompanied by one white rooster, twelve (12) colas, four hundred (400) cowries (now replaced by the sum of two thousand francs (2000 F) and tobacco for the applicant citizen of the village.

For an outsider, these offering also include the gift of thirty (30) litres of local brew (tchapalo) and the payment of a sum of seven thousand francs (7000 F). Furthermore, the applicant must agree to give part of the production carried out on the land to the chief. The last two conditions are renewable each year as long as the foreigner operates the plot that was granted to him.

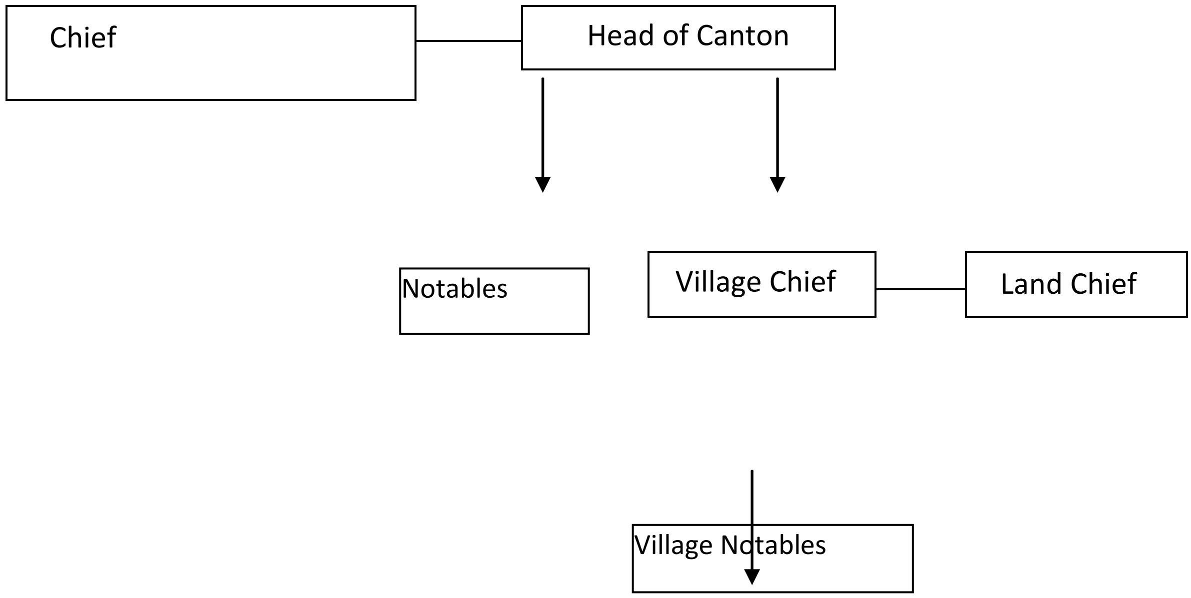
3.7.1.5 Socio-demographic characteristics

According to data of the General Census of Population and Housing (RGPH) of 1998, the localities of Pourou, Sissingue, Kanakono, Tialaka, Danzourou, Koutou, Djoguenesso, Mbasso, Danzourou, Basso, Ziékoundougou, Katara, Papara Doubasso, Tiongoly and Zanikan have a total population of 12,539 inhabitants, 6,506 women (51.87%) and 6033 men (48.13%).

Migration at local level: the data collected from populations show 77.32% of heads of households claimed to have a parent who lives in another village in the region or in another region of the country. The main causes of this migration in the project area are: livestock and agricultural activities (42.41%), the search and or purchase of gold (38.64%) and trade (18.95%).

3.7.1.6 Sociocultural characteristics

The social organization: two levels of social organization structure the project area: the Canton, administrative division of colonial origin and grouping of several villages and the village as an area of life. The social organization, at the project area described above can schematically be presented as follows :



Habitat: There is diversity of housing in the project area. In general, depending on the construction materials, there are five main types of houses (Photo 7) homes in geo mounted concrete with earth (41%), the permanent houses (19.15%), the battered mud houses (20.16%), the concrete houses geo mounted with cement (18.36%) and huts (1.45%). According to the data above, we can say that the habitat of the project area is fairly modern.

Battered mud houses

Permanent houses

concrete houses geo mounted with cement

Photo 7 Main house types

Cosmogony: The monotheist and animist beliefs coexist peacefully in the villages of the project area. Regarding the monotheistic religions, there is at least one mosque in every village, except Djoguenesso. Christianity through the Catholic belief holds three (03) churches including Kanakono, Pourou and Tialaka. Animism, however, seems to be the dominant religion, given the importance of sacred sites and traditional rites attached to them. Offenses related to the transgression of these prohibitions are subject to a penalty that rule by donations in kind. These are based on the severity of the offense: ox, silver, sheep, goats, poultry, red rooster, local drink (tchapalo).

In certain villages, it is noted that there are annual ceremony of minor spirit worship. The villages of the project area full of many sacred sites (Map 11) certainly reflect a cultural dynamism of the population and especially its worldview. These sites are usually first meeting places between the founding ancestor of the village and the protective deities, the supposed residences of gods or ancestors manna, places of special events, etc.

Map 11 Sacred sites of Sissingué

The education system: The education system in the project area mainly focuses on primary education. Eight (08) primary schools are located in the villages of Kanakono, Sissingue, Pourou, Kotou, M'basso, Danzourou, Katara and Papara. Despite efforts by the City, it will take a few years to ensure a better working and study environment, with several difficulties at the school level. In particular, the state of dilapidation of some local buildings including the pronounced lack of tables and benches for students and offices for teachers. For the education staff, the project area has a (01) Educational Consultant and eighteen (18) teachers.

3.7.1.7 Economic activities and infrasturcture

The survey shows that agriculture is the main socio-economic activity of the population. Indeed, 83.51% of the households we interviewed said that this activity is their main source of income. Farming, gold mining and trade occupy the remaining households, or just over 16%.

The agro-pastoral activities in the project area is dominated by cattle. It occupies an important place in the local economy. It should however be noted that this sector is still dominated by foreigners. The national interest for this activity is mainly associated with farm work.

Trade at the project area is devoted mainly to the sale of some manufactured products and other foodstuffs. Apart from a few small shops, the trade is at the weekly markets, the most important is in Kanakono.

The gold mining activities are carried out along the river, including Bagoue river. The latest gold panning site is one of Manandougou; two (02) kilometers from the locality of Kanakono.

According to many interviewees, gold panning would generate, for those who engage in it, significant financial gains. Also, this activity attracts many people including traffickers, prostitutes, etc. Compared to other socio-economic activities it provides daily earnings to various people in the production chain. It is said that one can make at least 11 000 CFA francs per day.

3.7.1.8 Infrastructure and equipement

The roads in the project area are mainly rural roads. In general, these roads are fairly well maintained and are therefore usable in all seasons.

Fixed telephone services provided at the department level by the Ivory Coast Telecom cover two areas of the project area (Kanakono and Sissingue). For cellular networks, the companies "Orange" and "Moov" cover the project area. Emissions of the national radio and television are well received in different villages. The electricity network covers only Kanakono.

Sissingue is currently powered by a group of functional generators. Regarding the provision of drinking water, it is generally assured through village hydraulic pumps. All villages have at least one hydraulic pump. It is worth mentioning that many water infrastructures are not functional.

Besides the infrastructure presented below, the villages in the project area are equipped with some socio-cultural facilities (**Table 3.28**).

Table 3.28 Sociocultural facilities in the project area

Sociocultural infrastructure and equipment	**Kanakono**	**Sissingué**	**M'basso**	**Tialaka**	**Djoguenesso**	**Pourou**	**Kotou**	**Danzourou**
Catholic church	X			X		X		
Methodist church								
Evangelical church								
Mosque	X	X	X	X		X	X	X
Public primary school	X	X	X			X	X	X
Housing for teachers	X (03)	X (03)				X(03)	X (2)	X (2)
Islamic school	X	X				X		
Pharmacy	X							
Maternity centre	X							
Housing for health personnel	X							
Cultural centre; youth centre	X							
Warehouse	X (02)	X			X	X		X (2)
Medical store	X							
Markets	X							
Functional village pumps	X (06)	X	X	X	X	X	X	X
Non-functional village pumps	X (03)	X	X					
Water tower	X							
Water supply	X							
Sports field	X							

Table 3.29 Sociocultural facilities in the project area (continued)

Sociocultural infrastructure and equipment	Gbini	Zanikan	Basso	Doubasso	Papara	Tiongoly	Ziékoundougo	Katara
Catholic church								
Methodist church								
Evangelical church								
Mosque	X			X	X	X		
Public primary school					x			X
Housing for teachers					X (5)			
Islamic school								
Pharmacy					X			
Maternity centre					X			
Housing for health personnel					X (2)			
Cultural centre; youth centre					X			
Warehouse								
Medical store								
Markets								
Functional village pumps	X (01)	X (01)	X (01)	X	X (2)	X (01)	X	X
Non-functional village pumps	X (01)				X			
Water tower								
Water supply								
Sports field					X			

3.7.2 Archeological Study

3.7.2.1 Introduction

The archaeological study of 22 May to 1 June 2010 and from 29 January to 6 February 2011 aimed to:

- perform a traveling survey of the entire sector of the extension of mining.
- identify sites that might contain the remains of cultural material accompanied if possible human remains or faunal fossils characterizing human activity from prehistoric times.
- map the different sites discovered.
- interpret the results and assess the importance of archaeological sites.
- make appropriate recommendations for prevention and possible protection of archaeological heritage, within the study area mining permit.
- advocate for additional work, possibly an intensive study of the sites that it would protect.

3.7.2.2 Study Methodology

The methodology is based on the chain of human evolution. Sectors, such as iron ore mining areas and nearby foundries (north-east Sissingue) were prospected.

3.7.2.3 Sites surveyed

Prospecting sight on Tengrela - Sissingue and Tengrela - Kanakono roads, and the permit area of Occidental Gold, achieved the desired objectives: the identification of archaeological sites, identification of discovered specimens, the inventory of sites and artifacts. There are thirty five (35) Sites (Map 12) and four hundred and eleven (411) remains were examined. On the highways, sixteen (16) archaeological sites have been discovered, of which eleven (11) ceramic fragments not associated with the lithic period and five (05) deposits within the Paleolithic era.

Map 12 Sampling points of archaeological sites and remains

In the study area, there were a total of twenty (20) fields including fourteen (14) in the northern sector (Sissingue and vicinity) and six others located in the southern sector (Kanakono, Kakpôlo, Zanikan, Gbini II). Among the fourteen deposits reported in the northern sector, two belong to the group of ceramic deposits not associated with stone implements, five deposits were attributed to the ancient iron metallurgy, and seven were defined as Paleolithic and some were grouped around Sissingue (Northeast , East, South-east) and others in Papara and Doubasso. In the southern sector, of the six deposits discovered five fall within the Paleolithic era and one within the Neolithic era. The first two are located in the northwest of Kanakono and the last in the East in the gold mining area (Kakpolô). No site attributed to ancient iron working has been discovered here. The three newly discovered are located further south of Kanakono that is to say Zanikan and Gbini II.

Paleolithic Sites

The distribution of Paleolithic sites in the study area shows fourteen (14) sites: nine (9) were observed in the study area and five in the bands of 500 meters on the roads.

Neolithic Sites

There is only a small number of relics from this time, including a fossil (an axe, 9 cm x 7 cm x 2.40 cm), taken in combination with ceramic fragments, in the furrows of a cultivated plain (project study area, at 2000 meters, in the northwest of Kanakono). Next to the axe, there was another form of fine craftmaship: scissors with dual blades (10 cm x 4 cm x 2 cm), made from quartz.

Ceramic fragment deposits

The ceramic fragments deposits are strongly present in the band of 500 metres on the northern road (Tengrela - Sissingue - Tengrela) and South (Tengrela - Kanakono - Tengrela). There are eleven (11) including six located on the main road north (Tialaka - Mbasso; Sissingue - Mbasso) and five (05) on the South road (Kanakono - Pourou; Pourou - Danzourou). In the study area, these deposits are very poorly represented (three cases only were observed in the Northeast and South -west of Sissingue).

Smelting sites

Metallurgical sites observed in the field, during the research, are located in the Southeast of Sissingue. They fall into two categories and can identify with the mining areas of iron ore and foundries.

The iron ore mining areas

There are three. all located in the vicinity of the Ivorian shore of Bagoé. The first of these ancient iron working sites is observable at 3400 meters from Sissingue on the hill 338 meters above sea level, overlooking the Bagoé valley. This hill is made up of laterites dismantled in several levels.

Foundries

Foundries are the second category of metallurgical sites. There are three sites, two of which are in ruins. The only clues to their existence are reduced to the presence of fragments of nozzles and genuine iron slag fields that littered the spaces where the activities of smelting iron ore might have flourished.

3.7.2.4 Socio-cultural importance

The collected archaeological remains covered at least the upper Middle Pleistocene and post Quaternary. A relative chronology based on the morpho-technical and typological characteristics of the lithic tools attest to the representation of cultural steps such as Acheulean complex, sangoens, Middle Stone Age (MSA), the Paleolithic, the Neolithic and ancient iron metallurgy (for the post-quaternary) whose practice on all cultural areas in Ivory Coast is no longer in doubt (Guédé Y. 2003). These investigations revealed a cultural diversity in prehistoric times in this region and contribute significantly to the enrichment of the national archaeological collection.

3.8 HEALTH ENVIRONMENT

3.8.1 Overview

There was an inventory of Community Health of the study area and surroundings. It aims to guide the partner in making any health decisions during the project's operational phase and on cessation of activities.

Tengrela has fourteen (14) health facilities (Map 13), two of which (2) are non-functional. The "Boubacar Tengrela Infirmary " is the only private facility care. Several local and international NGOs (Action Against Hunger, Health Alliance International) and UN agencies (UNICEF, WHO, WFP, PUMLS) are also present. The Community Based Organizations such as ANADER raises awareness for health action. The pharmaceutical structures consist of public structures (Pharmacy of Tengrela General Hospital, Pharmacy Health District Tengrela) and one private structure (Pharmacy Yacouba Sylla Tengrela).

Map 13 Location of health facilities

The main causes of morbidity are attributed to twelve (12) diseases: malaria, ARI, malnutrition, chronic diarrhea, dermatitis, anemia, typhoid fever, STI, TB, urinary schistosomiasis, Buruli ulcer and leprosy.

The relation used to calculate the impact is:

Incidence (‰) = (Total number of cases by pathology x1000) / Population with: Population (Tengrela) estimated at 88 606 inhabitants.

Table 3.30 below shows causes of morbidity by age.

Table 3.30 Leading causes of morbidity by age

Diseases	0-11 M	1- 4 Y	5- 14 Y	15 Y +	Total	Incidence (%)
Malaria	835	2 508	849	3 868	8 160	92
ARI	418	771	184	635	2 008	23
Malnutrition	274	1 050	42	14	1 381	16
Acute diarrhea	350	577	84	358	1 369	15
Dermatosis	120	235	111	275	741	8
Anamia	95	358	44	62	559	6
Typhoïd Fever	9	2	30	317	358	4
STI	0	1	8	232	241	3
TBC	0	0	0	13	13	0.15
Leprsy	0	0	0	02	02	0
Buruli ulcer	0	0	01	07	08	0
Urinary schistoso	0	0	02	08	10	0

Malaria is the leading cause of morbidity representing 55% of total cases. Diarrhoeal diseases are a public health problem in Tengrela affecting 68% of children under 5 years. Acute respiratory infections (ARI) is the second cause of morbidity with an incidence of 23 %.

ARI is a public health problem in the department of Tengrela with a high prevalence in children under 5 years with 59% of cases.

Measles is a disease with epidemic potential for the Tengrela department with 3 cases reported in 2009.

3.8.2 Endemic diseases

Malaria: Malaria is the leading cause of morbidity for an incidence of 92% in 2009 with a high prevalence in patients over 15 years representing 47% of cases.

Sexually transmitted infections (STIs): In 2009, an adult population of about 46 420 inhabitants, we have been notified of 232 cases with an incidence of approximately 5 %.

HIV / AIDS: The start of activities dates back to September 2009.

The problems encountered relate to the irregular supply of strategic inputs. The number of detected HIV positive cases is 10 (Pregnant Women). The trend is on the rise at the gold mining at the site of Sissingue.

TB: For a county population of 88 606 inhabitants there were 13 cases of tuberculosis with an incidence of 0.15 %.

Leprosy: Leprosy is being eradicated in Tengrela.

The Buruli ulcer: 8 cases were reported with an incidence of 0.1 ‰. We note a resurgence of Buruli ulcer in Tengrela.

Urinary schistosomiasis: 10 cases with an incidence of 0.11 ‰ were recorded. This pathology is declining in Tengrela.

The following diseases have not been reported by the public health authorities: polio, river blindness, cancer, influenza, ulcer, hernia, hemorrhoids.

3.8.3 Method of Treatment (modern or traditional)

Preventive, promotional and curative care is provided in the department of Tengrela. Where possible measures have been taken to cover the needs of women of childbearing age (births), family planning, immunization coverage of children [DTP3 vaccine, polio, anti measles vaccine (VAR) and yellow fever vaccines.

The Departmental branch of the National Public Health Institute Tengrela is responsible for core activities, including vaccination and health checks at borders.

3.8.4 Influence of gold mining on the health of the population

In Tengrela, panning for gold is beyond the control of the administration. This activity provides income to thousands of families, mostly foreigners from the West African sub region. Mercury is used in gold panning. The miners will provide it as part of their black market business. It is an activity involving a significant number of women and children, including pregnant women and women carrying children on their back. No protective equipment is used. The people use mercury without knowing its toxicity to human health and the environment.

There is a mining code that gives authorization for Ivorians to practice small scale and artisanal gold mining. The Mining Code requires a prior environmental impact study for artisanal and semi-industrial miners.

Generally, the artisanal sector does not obey this legal procedure. Permissions were given to Ivorians by order of the Ministry of Mines. Mercury is banned in Ivory Coast, but it is sold in the black market.

The risks related to the use of mercury in this sector on the environment is severe. Mercury methylation is favored by the physico-chemical conditions of the aqueous medium, thus leading to more toxic and dangerous form of mercury for physical health. Artisanal mining in Kanakono encourages deforestation, soil degradation, air pollution by dust and carbon monoxide, soil and water pollution, loss of biodiversity and landscape deterioration.

The adverse effects of gold mining are numerous. They are mostly related to the hygiene of operating sites and dust powder released by crushed stone. The most exposed miners are those who practice the washing, panning and grinding stones. They are vulnerable to several skin and diseases in the short and long term.

For those who grind the stones, they are exposed to brain infections. According to opinions of doctors in the project area, approximately 35% of consultations on gold sites may have a direct relationship with gold panning. These may be diseases like bilharzia, typhoid, skin infections, meningitis, etc. Beyond these diseases, miners are exposed to other diseases related to mercury poisoning.

4.0 IMPACT ASSESSMENT

4.1 INTRODUCTION

Operating a gold mine, like any economic activity has an environmental impact. However, the nature and severity of disruptions caused depend on factors like the type of process, characteristics and sensitivity of the site and the methods of management and control of operations.

In this chapter, we present a description and analysis of the direct and indirect impacts, including those that are reversible and irreversible, cumulative, changes made to the processing plant, the location of tailing and the environment. Other works of the project, including the waste rock dump have not been modified. The analysis is essentially based on a matrix approach to interrelations between the activities of the project, sources of impacts, and elements of the surrounding environment. The impacts are described according to the criteria of intensity (Low, Average or strong), scope (on site, local or regional) and duration (short, long or Average).

Although the positive benefits of the project should greatly outweigh the negatives, continuous monitoring will be implemented to ensure that unforeseen negative impacts are identified and resolved. Minimising the potential negative impacts may be related to problems such as the blocking of access, the guarantee of jobs to local residents, or an influx of migrants seeking opportunities employment to the region. As a social partner, Perseus Mining Côte d’Ivoire, is committed to maintaining an ongoing dialogue with stakeholders in the region to identify and solve problems as they emerge.

The environmental protection measures envisaged by Perseurs Mining Côte d'Ivoire to control, mitigate or compensate for adverse consequences of gold mining, both during the construction phase and during the period of plant operation are described in chapter 5.0.

In addition, the section entitled "Preliminary Plan for Environmental Management" presents the first version of the environmental monitoring plan which will be updated by Perseus Mining early in the mine construction period. This support plan is a practical document containing all activities and measures to be undertaken by the company to control the environment, monitor the effectiveness of mitigation measures of the project, maintain permanent contact with the population and prevent potential accidents.

Activities related to the closure of the site are also described in a separate chapter, which is the Preliminary Plan for closure and rehabilitation of the project site.

It is important to note that Perseus Mining Côte d'Ivoire must conduct the construction, operation and closure of the gold mine in accordance with the requirements of the legislation of the Ivory Coast and international standards for mining operations, the safety of employees and the public, as well as respect for the protection of the environment.

4.2 IMPACT ASSESSMENT METHODOLOGY

4.2.1 Impact assessment

The potential impacts of the gold project and the mitigation measures have been identified, characterized and evaluated based on a methodology developed around the following elements:

- An analysis of the acquired data on the physical, biological and social environment of the area of the Sissingue gold project;
- An evaluation of the information obtained about the stages of development and operation of the mine. The outline of ore extraction, ore treatment process, water supply, treatment and storage of tailings, site preparation, etc. has been made, but some minor changes may be made in the implementation phase;
- The opinions and concerns collected by CECAF and Perseus from traditional populations and authorities (Village Heads and Heads of Earth) visited different villages in the area;
- Current regulation in Côte d'Ivoire, particularly the laws and decrees cited and the terms of reference prepared by ANDE;
- A comparison with similar gold projects developed under comparable environmental conditions in West Africa and particularly in Ivory Coast.

4.2.2 Impact assessment process and interaction matrix

The potential impacts of the project were evaluated in terms of intensity and duration, as presented in **Table 4.1**. Based on the evaluation criteria, a level of importance (minor, Average, major) is assigned to identify and assess potential impact in

Table 4.2.

The different combinations of the evaluation criteria (intensity, scope and duration) determine the level of impact significance (major, minor or Average) as presented in Table 4.2. In order to stay as objective as possible, the CECAF International Studies has taken a conservative approach to the designation criteria and their level of importance.

4.3 ANALYSIS OF ALTERNATIVES

In general the alternatives for mining projects are very limited because it must meet a large number of technical, environmental, social and economic characteristics that will dictate the design criteria of the project, and the location of various structures.

As part of the feasibility studies of the Sissingue gold project, the company conducted an analysis of alternative methods. It is presented in **Table 4.3** of this document.

As with any mining project, the nature of the ore dictates the method of operation. The metallurgical testing of ore showed the choice of the tank leaching method by cyanides, as the most effective method and most economical result. A heap leaching, as practiced in other mines, is not profitable for this type of ore.

Similarly, the location of project various works was determined based on several criteria including the lack of mineralization, proximity to sites, geotechnical conditions and the remoteness of the resident populations.

Table 4.1 Impact Assessment Criteria

CRITERIA	CATEGORY	DESCRIPTION
Scope or influence of the spatial impact	**Regional**	More than 10 km of the Project and its activities.
	Local	Less than 10 km of the Project and its activities.
	On site	On the Project activity site or 100 m from its border.
Impact intensity (measured from its scope)	**High**	Natural and / or social elements that are severely impaired.
	Average	Natural and / or social elements that are clearly impaired.
	Low	Natural and / or social elements that are slightly impaired
Duration of the impact	**Long term**	Greater than the life of the gold project (More than 6 months after discontinuation of operations).
	Medium term	During the life of the gold project
	Short term	During the construction or operation (less than 6 months)

Table 4.2 Determining the level of impact significance

LEVEL OF IMPORTANCE	CRITERIA LEVEL		
	SCOPE	INTENSITY	DURATION
MAJOR	Regional	High	Long term
	Regional	High	Medium term
	Regional	Average	Long term
	Local	High	Long term
AVERAGE	Regional	High	Short term
	Regional	Average	Medium term
	Regional	Average	Short term
	Regional	Low	Long term
	Regional	Low	Medium term
	Local	High	Medium term
	Local	High	Short term
	Local	Average	Long term
	Local	Average	Medium term
	Local	Low	Long term
	On site	High	Long term
	On site	High	Medium term
	On site	Average	Long term
MINOR	Regional	Low	Short term
	Local	Average	Short term
	Local	Low	Medium term
	Local	Low	Short term
	On site	High	Short term
	On site	Average	Short term
	On site	Average	Medium term
	On site	Low	Long term
	On site	Low	Medium term
	On site	Low	Short term

Table 4.3 Alternatives considered for the design phase of the Sissingue gold project

Impact of the Project	Alternatives and criteria considered	Option(s) selected
Project Devlopment	The project raises a number of positive and negative impacts on the biophysical and social environments. The objective of the environmental impact study is to quantify and determine the significance of potential impacts. If the global environmental analysis, after consideration of possible mitigation measures, had to conclude that the project would pose a significant problem on the different components of the environment, the non-development option	The investment and development of the project will be carried out if the results of the impact study on the environment and the financial feasibility study are positive.
Location of quarries	The location of quarries depends entirely on the position of the deposit.	No alternatives.
Ore extraction	A single method of open pit ore extraction was chosen for economic reasons.	Open pit.
Ore processing	The metallurgical tests on the oxide ore and sulfide were identified by tank leaching cyanide, as being the most effective and the most economical. Indeed, heap leaching does not effectively treat the sulphide ore type. Finally, treatment with mercury was not accepted because it is too polluting and dangerous to human health and the environment.	Ore processing based on the leach tank by cyanides.
Waste Rock Dump	The project area is rural and dominated by the cultivation of cashew, maize, sorghum and cotton. For economic reasons (ie waste transport costs), it is important that the Waste Rock Dump is located near quarries. All the sites reviewed in the surroundings have a similar occupation of land (crop and fallow). Therefore, the plateau southeast of the three quarries was chosen because it has a number of environmental benefits.	The plateau southeast of the three quarries was chosen because it has a number of social and environmental benefits.
Location of the processing plant	The processing plant must be located as close as possible to the quarry, on relatively flat terrain away from drainage areas. A site meeting all these criteria was found just north of the TSF.	There is only one site that meets all the technical, economic and environmental requirements. This is the area north of the TSF.

Table 4.4 Alternatives considered for the design phase of the Sissingue gold project (continued)

TSF Location	For reasons of stability and adequate risk management, it is best to locate this kind of work in the eastern part of the main works. This location has all the required characteristics, namely, stable and low land hydrogeologic vulnerability, plateau, no houses, no cultivated areas and a very sensitive ecological area. In addition, the chosen site is close to the area designated for the implementation of the treatment plant.	The site meets the technical, economic and environmental. The lithology of the site is covered with a layer of clay, metasediments and felsic (granite)
Electricity Source	The study showed that for the first year of operation, the supply of electricity to the project will be done from a diesel generator and from the second year from the National power grid from Boundiali.	First year, use of a diesel generator and connection to the national grid from year 2
Access roads	The existing access road from Tengrela requires heavier gravel to be made passable in every season for transport vehicles of all kinds, with adequate drainage system. The access roads to the various works of the project have been chosen to minimize environmental impacts	The works to access roads will be created and the road from Tengrela to the project site will be rehabilitated.
Accomodation camp	The accommodation camp site will be chosen in an area with low impact on the environment and not far from the main works of the Project.	The accommodation camp will be located on the access road to the Project.
Airstrip	Site of 1200 m long and 20m wide feasible any place southeast of the project	Compliance with national security requirements of the tracks, training
Wastewater treatment plant (WWTP)	Site is located northwest of the treatment plant 1 km as the crow flies from camp life.	The site promotes the flow of water by gravity after treatment.

4.4 STEPS OF SITE PREPARATION AND CONSTRUCTION PERIOD

The construction phase will begin with site preparation activities that should take place during the dry season to minimize the problems of bearing capacities of soils and the unavoidable impacts due to erosion of bare soil, including an increase of suspended solids and turbidity in surface waters.

Site preparation phase will start once the construction of the most important tracks is completed. Preparing the site of the quarry, the Waste Rock Dump, the tailings facility, the wastewater treatment plant of the processing plant and its ancillary areas (administration, maintenance workshops, warehouses and fuel depot) include: stripping of the vegetation and topsoil (except at the tailings site) which will be stored for rehabilitation, leveling surfaces and for the specific needs earthworks and compaction. To minimize the impact of site preparation, sedimentation basins will be built before the wet season.

It is important to note that stripping the vegetation gradually will depend on the space required for each structure identified above. For example, it will not be necessary to strip the entire surface of the tailings site for production and storage throughout the duration of the project. A borehole will supply running water and electricity will be provided by the national grid or temporarily by a generator.

4.5 IMPACT ASSESSMENT ON THE LANDSCAPE

4.5.1 Overview

The project area is located in the countryside between the Sissingue village and the Bagoé river that forms the natural border between Côte d'Ivoire and Mali 25 km southeast Tengrela.

The main landscape units encountered fall into four (04) large groups following the topographical sequence of the environment:

1. Average slopes formed by some hills and slopes. These are located in the eastern part of the Sissingue village and the northeastern part of the project area.
2. Gentle slopes corresponding to peaks that are located in the central and north of the project area. These ridges are represented by laterite outcrops and buttes summits often covered with old fallow grasses or odorata, the result of an old farm. The vegetation in the area is considered a sparse shrub savanna with some wooded and large grassy areas.
3. Floodplains mainly present in the southern part of the project area, and along the Bagoé river.
4. Substantially flat areas are found in the western area of the project. The vegetation is also sparse shrub savanna with some herbs. Note the presence of some shrubs along dried up streams during the dry season and appearing in the wet season.

In the Project area, the four landscape units suffered significant damage, particularly the cotton fields, cashew and mango plantations.

The project area has no established tourism potential and does not benefit from protective measures, like a national park.

4.5.2 Identification of sources of potential impacts

The assessment of impacts on the landscape was conducted according to the principle of identifying critical and sensitive areas, namely the area of the nearest dwellings (Sissingue) and rare and endangered plant species according IUCN (2008) and AKE-Assi (1998) of potential sites of works of the Project.

4.5.3 Impact assessment

Mining and implementation of various works of Sissingue gold project will result in stripping vegetation and a significant change in the topography of the site by creating artificial lines (three holes for quarries and some mounds for tailings).

The impact will be noticeable to the people of Sissingue and residents (farmers) who come from Kanakono to do field work. The impact of the mine on the landscape will take place in an already exposed area with no ecological, tourist or historical value. However there are some rare plant species identified by AKE-Assi (1998) that will be affected by earthworks in the construction phase.

Due to its geographical location and the topography of the site, this impact can be considered localized, low and long-term giving it an average importance (**Table 4.5**). It will not be noticeable more than a few kilometers from the site. However, specific mitigation measures must be considered during the rehabilitation and revegetation phase of stripped areas, which will help mitigate the long-term impact.

Table 4.5 Matrix of landscape impact

Identification and analysis of the impact			Impact Assessment			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Earthworks, mining and tailings storage	Landscape degradation	Permanent damage to the aesthetics of the site making it unattractive and difficult to live.	Local	Low	Long Term	**Average**

4.6 ATMOSPHERIC ENVIRONMENT

4.6.1 Airborne Particulates

4.6.1.1 Definition

An increase in the atmospheric concentration of particles can seriously affect the quality of ambient air. This type of pollutant can be generated by multiple sources or activities which generally fall into two categories:

- easily identifiable sources such as crushing, grinding, transport conveyors, machinery, motors;
- sources such as working with explosives, the transport of persons or materials on the laterite tracks, the action of wind on bare surfaces likely to generate dust.

These sources of impact are usually categorized as point sources and diffuse sources.

4.6.1.2 Identification of potential sources of impact during construction phase

During the construction phase, potential sources of dust will be localized and limited to the following activities:

- site preparation required for implementation of the works;
- movement of vehicles on the access roads to the site carrying the materials and equipment for construction works;
- the movement of vehicles on the roads of the site.

4.6.1.3 Impact assessment in construction phase

These activities, especially the movement of vehicles on the roads, will generate a localized formation of dust in the atmosphere. However, in the context of relative isolation of the project area and the location of the various structures compared to inhabited areas, these diffuse sources could present problems that are more related to road safety than environmental pollution: decreased visibility on the slopes may increase the risk of accidents. Indeed, the distribution of dust particles generated by movement of the vehicles is a local phenomenon. A road will be built before the start of construction that will allow access to the mine bypassing the Sissingue village.

This impact can be characterized as on site, short-term low giving it a minor (**Table 4.6**). However a number of specific mitigation measures should be considered to reduce the magnitude of the intermittent effect and difficult to quantify movement of vehicles on the roads.

Table 4.6 Matrix of Atmospheric Environment impact during construction

Identification and analysis of the impact			**Impact Assessment**			
Activity/Source of impact	**Impact identifie**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Movement of vehicles on roads	Dust formation	Timely and localized increase in dust levels can hinder users and increase the risk of accidents	On site	Low	Short Term	**Minor**
Earth works	Dust formation	Localized increase in fine particles that land on the vegetation	On site	Low	Short term	**Minor**

4.6.1.4 Identification of potential sources of impacts during operation stage

During the operating phase, potential sources of dust include:

- perforation, work with explosives and excavation of ore and waste rock quarries;
- loading and transportation of ore and tailings;
- ore crushing;

- conveyor and ore Dumps;
- movement of vehicles on dirt tracks;
- the action of winds on the exposed surfaces;
- combustion engines running on diesel.

As part of this assessment, the environmental effects were classified into two categories, namely fixed sources and diffuse sources.

4.6.1.5 Impact Assessment during operation phase

Fixed Sources

Four fixed sources in the processing area of the mine are likely to produce dust particles. These are: the ore crusher, the conveyor and the ore heap, carbon activated oven and gold melting furnace.

In general, the ore is sufficiently coarse and moist (15% water on average) to produce only small quantities of dust during crushing. Products levels should be below the threshold limit set at 50 mg / m3 by the World Bank.

This impact will be considered low intensity, on site and medium term, of minor importance (**Table 4.7**). Very simple mitigation measures will be taken to minimize the potential danger to operators working in crushing.

Table 4.7 Matrix of Atmospheric Environment Impact during operational phase

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Ore crushing	Dust formation from fixed sources	Timely increase in dust levels can affect the health of workers crushing station.	On site	Low	Medium term	**Minor**

Regarding the level of particle emissions by activated carbon regeneration furnaces and melting, it will be expected to use the mining equipment which complies with regulations and international standards on atmospheric emissions of fine particles (PM10) from fixed and mobile combustion installations. During the harmattan, it is normal to measure PM10 dust concentration in the atmosphere over 100 mg / m3, twice the levels recommended by the IFC in its October 2003 document.

This impact will be characterized as on site, small and medium term, giving it a minor (**Table 4.8**). No specific mitigation is considered as the level of emission generated by equipment that will be purchased is in line with international standards.

Table 4.8

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Combustion ovens	Dust formation from fixed sources	Small-time increase of PM10 dust levels. The particles disperse very rapidly in the atmosphere..	On site	Low	Medium term	**Minor**

Diffuse Sources

The amounts of dust from diffuse sources are influenced by two major climatic factors, namely wind speed and surface humidity. The project area receives more than 0.4 mm daily rain for about sixty days per year. Diffuse dust sources are composed of operations of explosions in the quarry and vehicle movements on laterite roads. We must also consider the action of the wind as a potential source of dust. This will be most important during the harmattan.

The explosives work is the source of that circumvents control. As part of this project, the remoteness of populations more than 3 km to the nearest village, the low ground speed winds (Average maximum speeds of 2.6 m / s), vegetation cover and the topography of the site should be considered as factors limiting the dispersion of large-scale dust. Only winds over 6m / s can disperse the fine particles in the atmosphere.

Wind speeds above 6 m / s are sufficient for the fine material particles deposited on the surface to be released into the atmosphere.

Explosives currently used by the mining industry are of the low breaking capacity, limiting release of materials and dust during use. The new working techniques of explosives can improve the sequence of explosions and thus reach the desired result while minimizing the required load.

The identified impacts are considered on site, low and medium term, giving it a minor (**Table 4.9**). No specific mitigation is to be considered in the environmental, geographic and demographic conditions of the project area. However, if the situation proves critical, the mining company could always consider putting in place mitigation measures such as intermittent watering or installing windproof stocks.

Table 4.9

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensit y**	**Duratio n**	**Importanc e**
Working with explosives	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries.	On site	Low	Medium Term	**Minor**
Wind on surfaces	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries	On site	Low	Medium Term	**Minor**

On dirt tracks, the dust will be produced by the movement of vehicles. Dust that might be generated during the drier periods could create a road safety problem. Although the layout of the various access roads and ore transport route was chosen to avoid the village of Sissingue, different users, including residents crossing the operating license, could be seriously affected.

The impact can be considered local, medium and medium term, giving it an Average importance (**Table 4.10**), requiring the adoption of mitigation measures to reduce these emissions.

Table 4.10 Matrix of Atmospheric Environment Impact during operational phase

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identifie**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Movement of vehicles on dirt tracks	Dust formation from diffuse sources	Timely and localized increase in dust levels may hinder the users of different tracks and increase the risk of accidents	Local	Average	Medium Term	**Average**

4.6.1.6 Identification and assessment of cumulative impacts on the atmospheric environment

Cumulative impacts from air emissions can come from the ore processing unit, the wastewater treatment plant and the airstrip.

Treatment plant

Indeed, at the plant, adding one (1) crusher in the processing chain to two (2) total would cause an icrease of dust. But the spatial extent of the impact, intensity, and duration are minimal compared to the original unit. Therefore, the addition of one crusher in the ore crushing chain does not change the matrix of impacts presented.

Similarly, the change in the absorption chain does not result in any change in the impact matrix of combustion factory furnaces.

This impact can be considered low, local and medium term, giving it a minor (**Table 4.11**).

Table 4.11 Matrix of Cumulative impacts associated with the addition of a third crusher on the Atmospheric Environment

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Adding a third crusher	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Local	Low	Medium Term	**Minor**

Wastewater treatment plant

Work on the construction of the wastewater treatment plant could cause an amount of accumulated dust. These quantities of dust are minimal compared to those generated on the project sites.

This impact can be considered low, on site and short-term, giving it a minor (**Table 4.12**).

Table 4.12 Matrix Cumulative impacts associated with the construction of WWTP on the Atmospheric Environment

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Construction of the WWTP	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	On site	Low	Short Term	**Minor**

Airstrip

Work on the excavation and operation of the airstrip could also result in a cumulative amount of dust during construction of the project. These quantities of dust are minimal compared to those generated on the project sites.

This impact can be considered low, local and medium term, giving it a minor (**Table 4.13**).

Table 4.13 Matrix of cumulative Impacts related to the airstrip construction on Atmospheric Environmental

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Construction of the airstrip	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Local	Low	Medium Term	**Minor**

4.6.2 Atmospheric Emissions

4.6.2.1 Definition

In addition to carbon dioxide (CO2), the main atmospheric emission emitted by diesel engines are sulfur oxides (SOx), nitrogen oxides (NOx) and carbon monoxide (CO).

4.6.2.2 Identification of potential sources of impact

The atmospheric emissions from the project activities will come from diesel vehicles, furnaces regenerating activated carbon, melting furnaces and some emergency power generators.

It should be noted that the fumes generated by explosives contain traces of carbon monoxide and nitrogen oxides. Tests carried out in other mines (Australia, USA, South Africa, etc.) along quarries during and after an explosion showed that their concentration is usually too low to be detected.

4.6.2.3 Impact Assessment

The equipment will be new and emission levels of the engines will comply with international standards. The machines and equipment will be regularly checked and maintained in mechanical workshops planned for this purpose on the project site.

Generally, the amounts of SO2 and NO2 produced in mines are low and disperse very rapidly in the environment.

Therefore, the impact on the region of engine emissions is considered negligible. This impact can be considered local, low and medium term, giving it a minor (**Table 4.14**), not requiring the adoption of any specific compensatory measures.

Table 4.14 Impact matrix of the Atmospheric Environment during operations

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Diesel engines	Production of greenhouse gases	Increasing carbon levels in the atmosphere and other gases (SO_2 et NO_2)	Local	Low	Medium Term	**Minor**

Fumes from the Laboratory

The analyzes performed on the laboratory generated fumes containing gas which must be removed from the premises of the laboratory. The quantity produced will be considered very low but still must be removed from the location, hence the need for air extractors. The impact can be characterized as on site, small and medium term, giving it a minor (**Table 4.15**).

An Aqua Regia filter is scheduled for processing laboratory fumes.

Table 4.15 Impact matrix of the Atmospheric Environment during operations

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importanc e**
Laboratory analyses	Gas emissions	Increase the amount of gas that would threaten the health of laboratory operators	On site	Low	Medium Term	**Minor**

4.6.3 Noise and vibration

4.6.3.1 Definition

Noise is normally described as unwanted sound which is produced by a source that causes vibration in its surrounding area. It is customary to classify the effects caused by noise according to the physical, physiological and psychological criteria.

4.6.3.2 Identification of sources of potential impacts

The gold mine and the processing operations will cause a local increase in the noise level in the surrounding environment. In the case of Sissingue gold project, we must distinguish two main categories of sounds:

- continuous or semi-permanent noise produced by ore processing facilities (crushing mill, compressors, pump motors) and vehicles (construction machinery and heavy equipment). The vibrations generated by these sources are generally small and localized;
- intermittent noise from irregular explosions in the quarry.

4.6.3.3 Impact assessment

Overview

The topography of the site and the lack of population in the project area within 1,000 meters of the most important sound sources allow to suppose that the level of impacts related to noise and vibration should not be very important. It should be noted that all high-use roads will avoid residential areas.

Continuous Noise

This category of noise will be produced mainly by mining activities and crushing. In principle, the people of Sissingue, who are located more than 3km from the site should not perceive a significant increase in noise in their environment. The expected noise levels in this village will be acceptable and therefore comply with IFC standards (Day- 55 dBAeq max per hour and Night- 45 dBAeq max per hour).

It should be noted that the measured noise levels in the project area over 24 hours are around 40 dBA. This impact is negligible in the geographical context.

For health and safety reasons, any worker operating in an environment where noise exceeds 85 dBA should wear appropriate equipment provided by the employer. For this kind of operation, the noise levels are generally achieved only near the crushers. This impact can be characterized as local, strong and medium term, giving it an Average importance (**Table 4.16**).

The noise generated by the activities set forth above, could also have a localized effect on wildlife such as temporary or permanent migration of species of birds and mammals. There is little information on the behavior of wildlife to noise. However, the experience of exploration work showed that several animal species very quickly accustomed to continuous noise, especially if their habitat is not destroyed. The study of the initial state revealed that the Sissingue gold project site and its immediate surroundings had a relatively low faunal diversity, which suggests that the impact of noise on wildlife site will be negligible.

Table 4.16 Impact matrix of noise and vibrations during operations

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identifi**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Crushers, processing plant and mining equipment	Continuous noise	Levels above 85 dBA noise can affect hearing ability of workers and the surrounding population	Local	Strong	Medium Term	**Average**

Noise from explosions

Explosives will be used for the extraction of laterite near the surface and more particularly in areas where the rock is hard from a depth below the soil surface. This activity will be irregular, with a variable frequency.

The level of noise and vibrations resulting from explosions, although mitigated by the use of modern techniques could have an effect on the village of Sissingue. Although this village is located outside the security zone of three quarries by more than 3 km, the noise could affect the inhabitants.

The vibrations could create cracks in buildings and mud huts. The negative effects of working with explosives, because of the consequences they can induce, were classified as local, average and medium term, giving the impact an Average importance (**Table 4.17**). However these effects can be mitigated by implementing relatively simple specific measures.

Table 4.17 Impact matrix of noise and vibrations

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Work with explosives in the three quarries	Noise and vibrations	Effects on the inhabitants	Local	Average	Medium Term	**Average**

4.6.3.4 Cumulative impacts of aeroplane noise

During operation of the mine, increased noise levels could be found in the area of the airstrip. The flights will be towards the mine site and Abidjan for the safe transport of gold bullion. The airstrip could also be used for emergency medical evacuation. The noise level in the mine site will increase. The impact will be felt among employees who work in this area, but will have hearing protection equipment.

This impact can be considered average, on site and medium term, giving it a minor (**Table 4.18**).

Table 4.18 Cumulative impacts of noise from the airstrip

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Takeoff and landing of aircraft on the runway	Increased level of noise	Aircraft could increase the noise level at the mine site during takeoff and landing	On site	Average	Medium Term	**Minor**

4.7 AQUATIC ENVIRONMENT

4.7.1 Surface Water

4.7.1.1 Definition

The project area belongs to the Bagoé river catchment that forms the natural border between Côte d'Ivoire and Mali.

The use of river water in the project area is limited. All surrounding communities are equipped with wells, although some farmers have reported occasionally drinking from the backwaters.

The surface waters of the project area have different characteristics in both seasons. PH values range from slightly acidic (7.23) to slightly basic (8.58).

As for bacteriological parameters, it was noted the presence of total and faecal coliforms indicates that surface water is contaminated and not recommended for human consumption without prior treatment. There is strong microbiological contamination of surface water that is more notable in the dry season. Indeed, the rainy period before the dry season has enriched runoff of surface water with environmental microorganisms.

4.7.1.2 Identification of the main types of impacts

The potential environmental effects of the Sissingue gold project on surface water would be of two types:

• local disturbance of the hydrological regime of the Bagoé river caused by excessive water pumping or siltation of the bed;

• degradation of water quality with a changing parameter such as pH, conductivity, suspended solids, cyanides, heavy metals and hydrocarbons.

Such changes have a significant impact on the ecological balance of the aquatic environment and the downstream use of this resource.

4.7.1.3 Identification of potential sources of impact in the construction phase

The main potential sources of impacts on the aquatic environment associated with the development and operation of the Sissingue gold project are:

- site preparation works with different stages of deforestation, surface blasting, excavation and compaction;
- accidental discharges of oil or hydrocarbons from a construction vehicle or container;
- discharges related to the development of the site.

4.7.1.4 Impact Assessment during construction phase

Site preparation

Site preparation activities include the discovery of soil by heavy machinery with consequent possible increase in suspended solids and turbidity in rivers in the project area. Normally, most of these activities should take place during the dry season to avoid silting of the Bagoé river. However, for other works (quarries, waste water and tailings), the construction period may extend over several seasons. In case of rain, runoff on these bare areas would result in suspension components for land that would fall into the river.

This impact can be characterized as local, medium and short term, giving it a minor (**Table 4.19**).

However, this indirect effect of runoff on the Bagoé River and its tributaries in the project area can persist after the construction period and therefore it is best to take action at this early stage.

Table 4.19 Impact matrix on the aquatic environment during the construction period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Site preparation and surface	Poor quality of surface water	Increase in silting of river	Local	Average	Short Term	**Minor**

Oil spills

The likelihood of accidental contamination of soil and surface water due to oil spill is low but cannot be overlooked. This impact can be characterized as on site, short term and average, giving it a minor (**Table 4.20**). However, for reasons of good environmental management, measures to prevent such incidents should be taken.

Table 4.20 Impact matrix on the aquatic environment during the construction period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Machine use in site preparation	Poor quality of surface water	Oil spills affecting river quality	On site	Average	Short Term	**Minor**

Effluent discharges related to site preparation

From the beginning of the period of construction, housing will be built and made available to senior staff. Some workers will stay in the neighboring villages or even Kanakono or Tengrela. Domestic waste generated by the presence of new people living on site could contaminate surface waters if not treated properly, through the increase of organic matter and pathogens (coliform).

This impact can be characterized as local, average and short term, giving it a minor (**Table 4.21**). However, for reasons of good environmental management mitigation measures to prevent contamination of surface water will be suggested.

Table 4.21 Impact matrix on the aquatic environment during the construction period

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Site preparation	Poor quality of surface water	Increased organic matter and pathogens (colifor	Local	Average	Short Term	**Minor**

4.7.1.5 Identification of potential sources of impacts during operating phase

Potential sources of impact during the operating phase are:

- changing watershed characteristics resulting from changes in the topography of the site;
- surface water withdrawal for the supply of the process;
- accidental discharge of water;
- discharge of mine drainage water;
- the effects of runoff on the TSF and other project works;
- drainage and acid leaching of Waste Rock Dump;
- discharge of domestic waste water;
- accidental discharges of oil from a vehicle, vessel or workshop;
- the discharge of chemicals during transportation and handling.

4.7.1.6 Impact assessment of the hydrological regime during operating phase

Several activities planned under this project could affect the hydrology of rivers in the region:

- the influence of structures on land that will change the conditions of watershed surfaces (change in topography);
- sampling of surface water (pumping of the Bagoé) for the supply process;
- discharge of mine water if the quantities produced are in excess of the water balance.

Changes in the topography

The construction of these structures has the potential to change the characteristics of the respective watersheds. Changes in topography and surface conditions may change the runoff coefficient and promote a more rapid flow of water on the affected surfaces in the watershed.

From a hydrological point of view, the impact on sub-watershed streams in the project area could be locally significant. However, this potential effect should be placed in the local context and it is unlikely that significant changes can be observed or measured downstream on Bagoé or its tributaries downstream of the project area.

This potential impact on the hydrological regime can be characterized as local, average and long term, giving it an importance Average (**Table 4.22**). It may nevertheless be minimized and controlled if adequate measures are taken at the design of the project.

Table 4.22 Impact matrix on the aquatic environment during the construction period

Identification and analysis of the impact			**Impact Assessment**			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Clearing the ground for works	Disruption of hydrological regime	Changing the runoff coefficient due to changes in topography and surface conditions that can foster a	Local	Average	Long Term	**Average**

Water supply

Several options were examined by the company for the supply of process water. The preliminary study (available sources, costs and environment) concluded that it would be better to use several sources, namely:

- pumping in Bagoé to supply the basin with untreated water;
- dewatering will be pumped to the supply basin's water treatment plant.

The Bagoé river is not used to support local needs such as drinking water or irrigation of fields. The potential impact on the hydrological regime can be characterized as local, average and medium term, giving it an importance Average (**Table 4.23**). This will require the mitigation measures to minimize the impact on the ecosystem during low flow.

Table 4.23 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Pumping water to fill the water balance deficit	Disruption of hydrological regime	Changing the flow rate and possibilities of Bagoé drying up of for extended periods, which may affect the aquatic ecosystem	Local	Average	Medium Term	**Average**

Water discharge from the mine

Water will be collected in sumps at the bottom of quarries then directed via a sedimentation basin, to the raw water supply basin near the treatment plant. All drainage will be used as the power source for the ore treatment process or for watering tracks (dust suppression). No water should be discharged into the environment except the case of a strong wet season or exceptional rainfall.

This potential impact on the hydrological regime can be characterized as on site, small and medium term, giving it a minor (**Table 4.24**). No mitigation measures should be needed.

Table 4.24 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Water discharge from the mine due to heavy rain	Disruption of hydrological regime	Slight modification of stream flow but should not affect the functions of the aquatic ecosystem, especially downstream of the project area	On site	Low	Medium Term	**Minor**

The following activities could affect the quality of surface water in the project area:

- accidental release of process water;
- discharge of mine water;
- the effects of runoff on the TSF and other project works;
- drainage and acid leaching tailings;
- discharge of domestic waste;
- accidental oil spills from a vehicle, vessel or workshop;
- chemical spills during transport and handling.

These changes could affect particular parameters such as pH, suspended solids, turbidity, color, cyanide, heavy metals and hydrocarbons. It is important to note that it is not necessary to discharge effluent in the natural environment because the water balance is in deficit. Only accidental spills could be the cause of pollution of the aquatic environment.

Spills of process waste

Nature of the waste

Residues obtained from the gold cyanidation process, will consist of water, fine ore particles, cyanides which will evaporate and decompose under the effect of photo-chemical and biological phenomena and some heavy metals such as iron, copper, zinc, aluminum, arsenic, etc. These metals are present in complex form with cyanides, in dissolved form or in insoluble form as arsenate or iron oxide. The pH of these residues will be close to 10.

Effluent cycle

Tailings will be pumped to the TSF where the liquid phase is brought to settle the solid phase. Once in the TSF, the decant water will be diluted by rain water. In addition, cyanide that will be present in free or low complex form will be subject to natural degradation phenomena by ultraviolet and bacteria. These cyanides may also form very stable complexes with metals such as iron.

From the TSF, all the water will return to the process plant by a system of floating pumps. No effluent will be discharged into the rivers of the area. Thus, at any time, cyanides are not in direct contact with the environment. In addition, the pH of the liquid phase is maintained around 10-11 to work with cyanides, which are in a stable form in solution. It is not to the advantage of mine to have lower pH values because volatile cyanides massively increasing the risk of accidents and operating costs.

Seepage from the TSF will be retrieved by a system installed at the base of the dikes. It will consist of a trench that will collect seepage at the interface. Such seepage of water will be collected in a small pond built downstream of the dam, and then pumped to the tailings or to the ore processing plant to be used in the process.

Discharge of effluents containing high concentrations of cyanide and other toxic compounds will be avoided as much as possible. Indeed the ore treatment process will operate in a closed circuit and all liquid waste will be recycled and reused. However, we must not overlook the probability of an accident (leakage of a pipe, hose rupture, leak at a pump, overflow of a leach tank, etc.).

This potential impact on the quality of water can be characterized as local, high and medium term, giving it an Average importance (**Table 4.25**). Specific mitigation measures and the emergency response will be in place.

Table 4.25 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Accidental discharge of effluent following the drilling of a pipe, hose rupture	Poor quality of surface water	Effluents containing cyanide that reach waterways can have a negative effect on the aquatic ecosystem downstream of the project	Local	High	Medium Term	**Minor**

It should be noted that effluent containing cyanide could be released into the environment only after a series of exceptional rainfall. Under these particular conditions, the concentrations of cyanide spillage would actually be very low because of the massive effect of dilution by the huge amount of rainfall.

Problems due to the discharge of mine water

The water pump will be used as the power source for the ore treatment process or for watering tracks (dust suppression). Nothing should be discharge into the environment except perhaps for a strong wet season.

The drainage could be released into the environment without treatment. However, due to the presence of arsenic in rock, there is a risk that the concentration of this metal increases in the mine when including quarries that reach a depth at the level of transitional ore. The discharge standard advocated by the World Bank is 0.1 ppm arsenic.

If discharged, the potential impact on the quality of surface water can be characterized as on site, low and medium term, giving it a minor (**Table 4.26**). Specific mitigation measures must be put in place. The quality of dewatering should be monitored regularly, particularly in regard to the concentrations of arsenic.

Table 4.26 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Water discharge into the environment in case of heavy	Poor quality of surface water	Potential deterioration of the quality of streams that could affect the functions of the aquatic ecosystem	Local	Low	Medium Term	**Minor**

Waste Rock Dump Runoff

One possible consequence of the runoff effect on the Waste Rock Dump and other works of the project is sediment transport that can cause pollution of surface water by increasing concentrations of suspended solids.

This potential impact on the quality of surface waters can be characterized as local, average and medium term, giving it an importance Average (**Table 4.27**). Specific mitigation measures will be implemented at the design of the project.

Table 4.27 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Waste Rock Dump and other project areas	Poor quality of surface water	Possibility of siltation affecting the functions of the aquatic ecosystem	Local	Average	Medium Term	**Average**

Oxidation of sulfur rock and acid drainage formation

Drainage acids are produced by oxidation phenomena of materials (rock) containing sulphides following exposure to air and water. The possible production of acid, and especially sulfuric acid, would result in the dissolution of metals in these rocks. The environmental consequences of acid drainage can be substantial but mitigation measures are known.

The potential impact on the quality of surface water can be characterized as on site, low and medium term, giving it a minor (**Table 4.28**). Specific mitigation measures must be in place. During operation, the potential acid tests will be carried out on tailings and ore samples following extraction from the quarry.

Table 4.28 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Oxidation of sulfur rock and acid drainage	Poor quality of surface water	Drainages acids formed during oxidation of rocks containing sulfides can generate toxic effluents in the aquatic environment	On site	Low	Medium Term	**Minor**

Domestic effluents

Domestic effluents from residential camp will be collected and drained into septic tanks.

For some remote sites and the various administrative and technical buildings, it will also be necessary to treat the effluent in septic tanks built to international standards. However, the volumes of effluent generated will be relatively low.

Untreated, these effluents can contaminate surface water by increasing organic matter and pathogens (coliform). The contents of septic tanks should be properly disposed of without risk of environmental pollution. This impact can be characterized as local, medium and medium term, giving it an importance Average (**Table 4.29**).

Table 4.29 Impact matrix on the aquatic environment during the operation period

Identification and analysis of the impact			Impact Assessment			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Domestic effluens and contents of septic tanks	Poor quality of surface water	Increased organic matter and pathogens (coliforms) can contaminate surface water	Local	Average	Medium Term	**Average**

Hydrocarbon losses

A quantity and variety of important hydrocarbons will be present on site. Several types of oils and fats are necessary for the maintenance of mining equipment, transport vehicles and machinery in the factory.

Hydrocarbons could be introduced into the environment, following a technical failure of a machine, from the runoff water collected in workshops or maintenance of the hydrocarbon deposit or from a tank during a transfer of such products.

This impact can be characterized as local, average and medium term, giving it an Average importance (**Table 4.30**). To avoid contamination of surface water and soil, environmental management measures to prevent such incidents and mitigation measures will be taken at project design stage.

Table 4.30 Impact matrix on the aquatic environment during the operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identifid**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Hydrocarbon leakage into the environment	Poor quality of surface water	The presence of large quantities of hydrocarbons on the site, the use of vehicles and heavy equipment and their maintenance requires special management to prevent their loss to the	Local	Average	Medium Term	**Average**

Chemical spills

During the transportation and handling of chemicals, there could be a spill following a traffic accident or mishandling. Large amounts of chemicals may end up in the rivers. The probability of this accident happening is very low.

This impact can be considered local, high and long term, giving it a major importance (**Table 4.31**).

Table 4.31 Impact matrix on the aquatic environment during the operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Chemical spills	Poor quality of surface water	The presence of significant amounts of chemicals in rivers. A good convenient transportation and handling of these chemicals should be taught to officers committed	Local	High	Long Term	**Major**

4.7.2 Groundwater

4.7.2.1 Definition

Groundwater from dewatering in quarries will be used only to supply the tank with untreated water and to reduce dust on the roads. Also, it is possible that some wells are drilled to meet the quality requirements.

4.7.2.2 Identification of potential sources of impact during construction phase

The groundwater quality during the construction phase could be altered by leaching of heavy metals from works such as the tailings or wastewater.

4.7.2.3 Impact assessment during construction phase

Construction and adequate management of the TSF, combined with the acid potential of materials to be stored there, can indicate that the problems of leaching and heavy metals should be very limited or non-existent. No impact is anticipated.

4.7.2.4 Identification of potential sources of impact during operation phase

The groundwater quality during the operation phase could be altered by a leaching of heavy metals from works such as the TSF or tailings itself.

4.7.2.5 Impact assessment during operation phase

The daily demand for drinking water is to be determined. A daily volume will be filtered and treated before being stored in a tank and supplied to the network for this purpose.

The amount of groundwater needed for the project's daily needs will be considered low.

This impact can be characterized as local, low and medium term, giving it a minor (**Table 4.32**). Overuse of filters that could result in a general reduction of the ground water is not considered. No mitigation measures required.

Table 4.32 Impact matrix on the aquatic environment during the operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Pumping for potable water	Poor quality and decrease in the amount of	Pumping rates will be low and consistent with the nature of the aquifers in the project area. No impact should be observed.	Local	Low	Medium Term	**Minor**

Potential impacts due to seepage from works.

The site chosen for tailings disposal will be of low permeability given the planned development. Control and recovery of seepage water are included in the TSF design.

Without this system of recovery of seepage water, this impact can be characterized as local, high and long-term, giving it a major (**Table 4.33**) Indeed, the seepage water could contaminate the deep filters (fracture type) and the surface water downstream.

Table 4.33 Impact matrix on the aquatic environment during the operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Seepage from the tailings	Poor quality and decrease in the amount of groundwater	Water seepage circulating in the groundwater of the regolith and could result in long term contamination of deep groundwater (fracture type) and surface water downstream	Local	High	Long Term	**Major**

Potential impacts due to seepage following the chemical spill

The groundwater quality could be affected by seepage of chemicals following a spill during transportation or handling.

There is a need for policy regarding: chemical handling procedures according to international standards; Chemical transport conditions; the conditions of chemical storage; unloading procedures; the effective and immediate cleaning of a spill, as the long-term infiltration of these chemicals could affect groundwater.

This impact can be characterized as local, high and long-term, giving it a major (**Table 4.34**).

Table 4.34 Impact matrix on the aquatic environment during the operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identifid**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Seepage of chemical products	Poor quality and decrease in the amount of groundwater	Chemicals penetrating the ground water and long term contamination of ground water (fracture type)	Local	High	Long Term	**Major**

4.8 ECOLOGICAL ENVIRONMENT

4.8.1 Basic principle and identification of potential sources of impact

The basic principle is the accepted fact that this kind of project, like any economic activity, will have an impact on the ecological environment, which may cause harm or changes in the composition of species.

According to the initial plans, the construction activities and the project operation phase will cause a loss of bush and farm land.

The development of the project will generate sources of potential impact on the ecological environment of the area, which can be classified into three categories:

- the location of project works may cause harm to the ecological environment, including the destruction of particular areas;
- during the operating phase, presence of pollutants (dust, noise, vibrations, waste) that can disrupt a particular ecological balance;
- an increase of certain activities indirectly related to the project such as increased hunting and tree cutting for firewood.

4.8.2 Impact assessment

4.8.2.1 Impacts related to the location of site

The selection of the site is primarily guided by the ore concentration in the rock for the location of quarries and the absence of mineralization for other works. There are other factors such as the proximity of the sites, as well as the geotechnical characteristics, hydrogeology, topography, and finally the environmental and socio-economic conditions that can contribute significantly to the abandonment of a site previously identified as suitable.

In the context of the present project, the construction of the quarries, TSF, Waste Rock Dump and processing plant should at no time cause harm to forests, fragile habitats or areas with significant ecological value.

The majority of rare species in Ivory Coast identified on the site are located in areas that will be untouched by the development of the project except Detarium microcarpum of the Caesalpiniaceae family and Uvaria tortilis of the Annonaceae family (see Map 6)

This impact on the fragmentation, destruction of rare species or habitat loss can be characterized as local, average and medium term, giving it a minor (**Table 4.35**). However, mitigation measures will be proposed for the loss of vegetation.

Table 4.35 Impact matrix on the ecological environment during the construction and operation period

Identification of impact			**Impact assessment**			
Activity/Source of impact	**Impact identifid**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast)	The development of the project should not cause the destruction of forests or habitat with significant ecological value.	Local	Average	Medium Term	**Minor**

4.8.2.2 Impacts on fish and wildlife

The various mining and ore processing could cause harm through noise, dust, or accidental release of toxic effluents, and also create risk areas for wildlife and the occurrence of water bodies containing cyanides (various basins in the processing unit). These activities may be responsible for local changes to certain animal species.

Moreover, at the end of mining operations, the presence of massive holes could lead to very serious consequences on the lives of animals, reptiles and other mammals. Steps must be taken to avoid trapping these animals.

Despite the measures limiting noise, dust formation or discharges containing cyanides, it is not possible to make exact predictions regarding the level of potential impacts. Some groups of species such as fish or birds could be considered populations at high risk of exposure to pollution. For example, there is a potential risk of death to birds that may drink from the tailings. However, in the project area, which is neither ecologically rich nor a bird migration route, this impact can be considered local, low and medium term, giving it a minor (**Table 4.36**).

Table 4.36 Impact matrix on the ecological environment during the construction and operation period

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Different mining activities	Harm (Noise, dust, waste) from Project activities on wildlife	Some groups of species such as fish or birds are populations at higher risk of exposure to pollution generated by the project.	On site	Weak	Medium Term	**Minor**
	Trous et fossés	The animals could fall and be trapped in the holes or pits dug during the construction phase and operation	Local	Average	Long term	**Average**

4.8.2.3 Impacts of the operation of the airstrip on wildlife

The presence of wildlife at the airstrip can interfere with airport operations and therefore represent a potential security risk. There are not high numbers of large mammals in the study area, the risk of accidents with small mammals (mainly on birds) might be possible during takeoff and landing of aircraft at the mine.

This impact can be considered average, on-site and medium term, giving it a minor (**Table 4.37**).

Table 4.37 Impact of aircraft on wildlife

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identifie**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Takeoff and landing	Risk of accidents by hitting birds or mammals	The risk of accidents can occur on runways by hitting birds or mammals	On site	Average	Medium term	**Minor**

4.8.2.4 Indirect effects of the Project

A mining project developed in a rural area such as that of Sissingue can have significant indirect effects on the ecological environment. The population of the surrounding areas may increase significantly with the likely result of an increase in hunting and the chopping down of trees for firewood. The actual impact on these resources is already significant as revealed by studies of the initial state.

The impact of the Project can be characterized as local, average and medium term, giving it an importance Average (**Table 4.38**). Measures will be proposed to offset these negative impacts.

Table 4.38 Impact matrix on the ecological environment during the construction and operation period

Identification of impact			Impact assessment			
Activity/ Source of	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Influx of population in the project area	Indirect effects on the ecological environment	Increase in hunting and the chopping down of trees for firewood	Local	Average	Medium Term	**Average**

4.9 TERRESTRIAL ENVIRONMENT

4.9.1 Identification of sources of potential impact

Potential sources of impact associated with the development and operation of the project are:

- excavation activities for the implementation of various works of the project;
- occupation of land necessary for the project development in areas already mined or used by other parties;
- soil contamination by oil or other chemicals..

4.9.2 Impact assessment

4.9.2.1 Soil erosion and sedimentation

The various activities of site preparation and the exposure of large areas of land can lead to soil erosion, as well as the leaching of fine particles which may cause pollution of surface waters by increasing concentrations of suspended solids, turbidity or colour change.

Various natural and man-made factors are involved in the process of erosion, such as rainfall, lithology and slope, or following a clearing:

a) Precipitation is one of the major factors of erosion. The intensity and energy of the water is responsible for the effect.
b) Structural stability and the particle size determine permeability. Infiltration rate is important. The layer of litter and organic matter content increases soil permeability. Humic and clay colloids maintain agglomerated sandy and silty particles and adjust the retention capacity of soil water. Unfavorable chemical composition (deficit bases) promotes the dispersion of colloids.

c) A low slope encourages infiltration and strong runoff, causing the runoff of surface soil. A continuous length of slope may considerably amplify the erosion phenomenon related to the inclination.

d) The vegetation is a shield against precipitation and thus erosion. The vegetation cover prevents rain from falling directly on the ground. Moreover, the mechanical action of roots protects the soil in keeping it in place and increasing the cohesion of the topsoil. The contribution of organic matter improves soil structure and cohesion. The roots reinforce the porosity of the horizon and oppose an obstacle to runoff.

Surface runoff observed at the project area is already a cause of noticeable erosion, illustrated by the presence of ditches, is characterized by the importance of the clay filler surface water after each rain. The presence of soil regularly exposed by fires and torrential rainfall are factors conducive to erosion. For tropical lateritic soils in which the nutrients are concentrated in surface, erosion contributes to their loss. Mitigation measures to promote soil conservation and structure must be taken.

Various site preparation activities that will occur during the construction phase but also during operation, may be responsible for a one-off phenomenon of soil erosion. A number of measures are proposed to minimize the impact of the project can be characterized as on site, average and medium term, giving it a minor (**Table 4.39**).

Table 4.39 Matrix Environmental Impacts soil in periods of construction and operations

Identification of impact			**Impact assessment**			
Activity/ Source of	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
The various activities of site preparation and the exposure of large areas of land	Soil erosion	Site preparation activities can lead to loss of land, while leaching of fine particles may cause pollution of surface waters	On site	Average	Medium Term	**Minor**

4.9.2.2 Soil Contamination

Poor handling or accidental release of hazardous chemicals during transport could contaminate soil. Good practice for handling and transport of these dangerous chemicals will limit this impact.

Also, soil quality could be affected by infiltration of heavy metals from works such as the TSF or tailings poured. Proper construction and management of the TSF, associated with a net acid potential of materials to be stored there should limit the problems of leaching and heavy metals.

This impact can be considered local, strong and long-term, giving it a major (Table 4.40).

Table 4.41 Matrix Environmental Impacts soil in periods of construction and operations

Identification of impact			Impact assessment			
Activity/ Source of	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Poor handling or accidental release of hazardous chemicals	Soil erosion	Poor handling or spills of hazardous chemicals and seepage of heavy metals from works such as the TSF or tailings poured could contaminate the soil.	Local	High	Long Term	**Major**

4.9.2.3 Impacts on agriculture and farm losses

The land use study and the agrarian census data were used to assess the potential loss of agricultural land and associated incomes of different fields and plantations. Of the 47,477 hectares surveyed, the total area under cultivation was 4895.18 hectares with a total of 1219 agricultural operations and 778 farmers. The distribution of cultivated land by types of crops that could be lost due to the development of the project is presented in **Table 4.42**.

Table 4.42 Distribution of acreage by crop types on the Project Area

Type of crop	Acreage	Percentage (%)
Corn	804.44	16.43
Cotton	527.02	10.77
Cashew	1351.04	27.60
Rice	185.62	3.80
Mango	24.63	0.50
Sorghum	172.7	3.53
Peanut	12.14	0.25
Combination of cashew and cotton	84.86	1.73
Combination of cashew and sorghum	9.57	0.20
Combination of cashew and corn	110.69	2.27
Combination of cashew and food crops	561.66	11.48
Combination of cashew and mango	30.23	0.62
Combination of cashew, mango and	37.42	0.77
Combination of various food crops (corn, sorghum, peanuts)	623.64	12.74
Other crops	285.43	5.83
Newly cleared land	37.04	0.76
TOTAL	4895.18	100.00

The crop system of the project area can be defined as a polycrop system based on cashew. Its location and its success are determined by the physical characteristics of the soil. Cashew plantations are almost all new. Their ages range from 5 to 10 years. Cotton growing is an old tradition in Tengrela.

The impact of the project can be characterized as local, strong and long-term, giving it a major (**Table 4.43**). Compensatory and accompanying measures will be proposed to offset the negative impact of the project.

Table 4.43 Matrix Impacts Land use in periods of construction and operations

Identification of impact			**Impact assessment**			
Activity/ Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of project works and road construction	Destruction of farms	The development of project works will cause a loss of farming	Local	High	Long Term	**Major**

4.10 IMPACTS ON WATER, SOIL, CAMP AND ADMINISTRATION

Wastewater from the administration and life base can be divided into two groups: domestic sewage and storm water.

Domestic sewerage has huge environmental risks. Untreated, they can contaminate surface water including an increase of the organic matter and pathogens (coliform). The discharge of domestic sewerage also has a potential for cultivated soils, crops, farmers, and for consumers. The sewerage usually contains a significant amount of micropollutants such as pharmaceuticals and hormones excreted in urine. Large amounts of salts is added whose accumulation in fertilized soils can lead to salinisation or even sodisation. Excess levels of some ions, such as sodium (Na +) and chloride (Cl-), can cause toxicity or deficiency of some nutrients in plants. The negative effects of high soil salinity will cause stunted growth caused by the inhibition of germination, which could cause lower agricultural yields. Unwanted components of gray water such as oils and fats and surfactants or surfactants will also in the long-term, lead to a low permeability of soils irrigated with adverse consequences on agricultural productivity and sustainability of the environment. The sewerage will be drained through a sewer system to the treatment plant and undergo several processing steps to meet the discharge standards.

The impact of the project can be considered local, low, medium-term, giving it a minor (**Table 4.44**).

Table 4.44 Interactive impacts on water, soil, crops related to the operation of the camp and Administration

Identification of impact			Impact assessment			
Activity/Source	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Operation of the camp and administration	Increased organic matter in surface water, soil infertility, decreased agricultural yields	Domestic wastewater may cause an increase in organic matter in surface water, leading to soil infertility, low permeability of irrigated soils and declining agricultural output	Local	Low	Medium Term	**Minor**

4.11 HUMAN ENVIRONMENT

4.11.1 Socio-economic impact assessment

4.11.1.1 Positive impact assessment

General positive considerations

The positive impacts of the project will focus primarily on the economic benefits that will have short and long-term positive effects on the social environment. The revenue growth for the region may result in infrastructure including improvements and services.

On a regional and national level, the project will have positive impacts on employment, training, allowances and taxes, purchase of manufactured goods and services or sold in the national territory and finally the quantity of gold produced, which should increase the official production of the Ivory Coast.

As with any mining project, the opening of the Sissingue mine will have positive and negative impacts on socio-economic aspects of the region. However, it is realistic to suggest that the positive aspects will considerably outweigh the negatives. These positive impacts can be characterized as regional, average and long term, giving them a major (**Table 4.45**).

Training

The extraction and processing will require a range of occupations with special expertise. A training centre will be created for employment, but also to instruct and educate people in environmental issues, hygiene and safety. Priority will be given to traing young people in Sissingue and Kanakono in general.

Employment

Although no recent statistics are available on the region, the unemployment rate would be very high, especially among young people who constitute a significant part of the population. This situation has worsened with the political and military crisis.

Initial estimates for employment include 40 expatriates and 283 Ivorians.

Taxes

The Government is a shareholder entitled to 10% of the dividends for Sissingue. Moreover, Perseus Mining will be subject to payment of a proportionate fee, the amount will be determined by the Mining Regulations and the annual payment area taxes.

In addition to the sources of income mentioned above, the Government will collect an income tax, a withholding tax on the value of services provided by non-registered companies in the country, a tax on employee wages and a tax on the importation of certain products.

Table 4.45 Positive impacts on the socio-economic environment

Identification of impact			Impact assessment			
Activity/Source	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Creation of new jobs	Training and employment	The project will create about 300 direct jobs and many temporary jobs. The training will be at the heart of the project development	Regional	Average	Medium Term	**Major**
Payment of taxes	Royalties	Improving the living conditions of the population through the payment of taxes to the State of Côte d'Ivoire to strengthen the infrastructure of the region.	Regional	Average	Long term	**Major**

4.11.1.2 Negative impact assessment

Population displacement

The mine's operating activities can significantly alter the tranquility and daily habits of the area. In some cases it might be necessary to move people to distant sites.

To ensure optimum development conditions of the Sissingue gold project, and ensure the safety and well-being of the population of the village, Perseus Mining Ivory Coast will begin a displacement procedure (physical and / or economic) to a site that meets the following minimum criteria:

- is sufficiently distant from project activities that generate pollution;
- is in an area where land is stable and without potential for flooding;
- have easy access;
- if possible be relatively close to new lands for the development of crops for those who have lost their plantations and would not want to invest their compensatory funds in other activities (alternative development projects).

Perseus Mining Ivory Coast acknowledges that only a participatory approach will lead to equitable development of the project and the solutions included and accepted by all. Population displacement, even on a small scale, is considered a very complex process that is carried out by well-defined stages. Maintaining a continuous dialogue with the affected parties and the implementation of concrete actions are the only way to gain their trust.

Past experience has shown that population relocation projects can succeed only if the people are offered better living conditions than their current location.

According to the preliminary plan, no village is affected by the mining activities Sissingue. However, some isolated hamlets on the perimeter could be.

The impact of the project can be characterized as local, strong and long-term, giving it a major (**Table 4.46**). Proposed mitigation measure will reduce this negative impact.

Table 4.46 Matrix of negative impacts on socio-economic environment

Identification of impact			**Impact assessment**			
Activity/Source	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of various project works	Displacement of the population in nearby hamlets	Some isolated hamlets on the location of important works would be affected. Any population displacement is considered a very complex process because it requires not only ensure a new home (if	Local	High	Long Term	**Major**

Perseus Mining Ivory Coast will compensate anyone with fields located on or near works of the project.

Problems relating to potential migration and population growth

Mining operations are generally accompanied by large influx of people seeking employment. In an area where the infrastructure is poor, such migration may have negative socio-economic and environmental impacts.

The beginning of the construction period will increase the number of people from the department or elsewhere, to settle in the surrounding villages to seek employment at the mine. Some of them will remain there for the duration of the project.

Any increase in population in the villages, which already have inadequate basic infrastructure may increase the magnitude of the problem. Furthermore, an additional influx of 'foreigners' can cause tensions between indigenous peoples and non-indigenous immigrants.

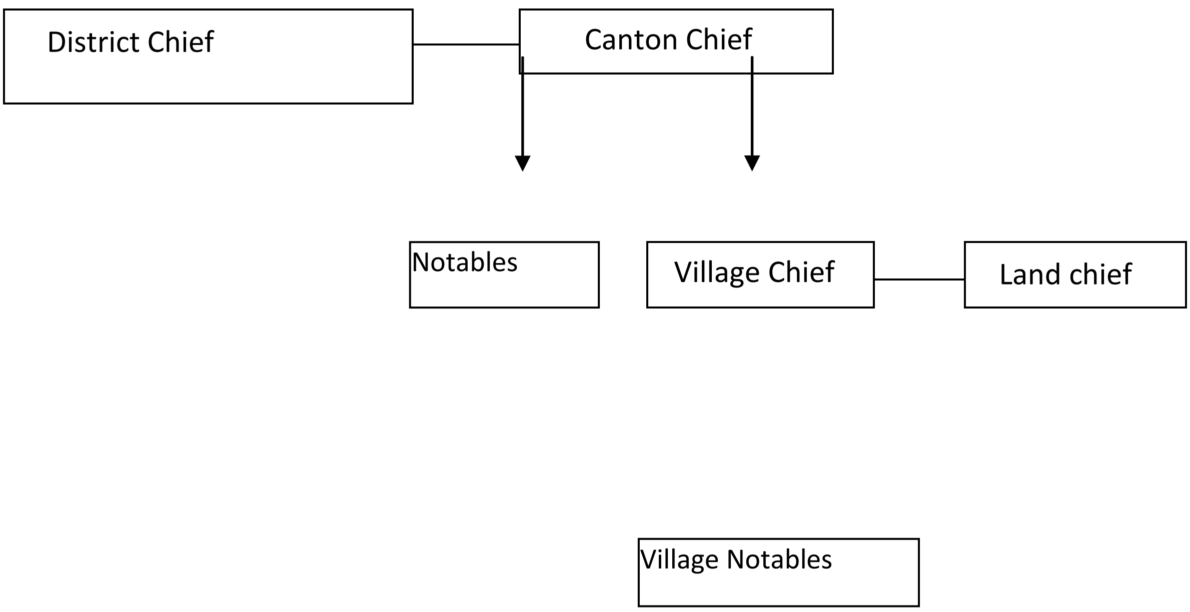
This impact can be characterized as local, strong and medium term, giving it an Average importance (**Table 4.47**). Mitigation measures will be implemented to minimize any potential incident. All parties concerned should be involved in this process.

Table 4.47 Matrix of negative impacts on socio-economic environment

Identification of impact			**Impact assessment**			
Activity/Source	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Massive influx of population	The opening of the mine in the area will attract a number of people looking for work. Any increase in population in villages already inadequate basic infrastructure can enhance the magnitude of the problem. On the other hand, an additional influx "Foreigner" can increase tension between indigenous peoples, immigrants and non-indigenous	Local	High	Medium Term	**Average**

Social Organisation

The social organization, at the project area is as follows:



In general, the district chief is the direct descendant of the land chief of the capital of the Canton. This is a family positoin held by the eldest of the heirs and cannot be switched. Inducting the chief is organized by a council of elders (guarantors of the tradition) composed of representatives from each village in the canton.

Except Kanakono who uses voting, local power at the village level is exercised by a leader whose selection is based on membership in the narrow lineage of the founding ancestor. The village chief induction proceeds from a decision of the council of village elders who know in advance which family returns to power. Within the designated family, authority is inherited by the eldest son.

The village chief is assisted in their work by a notability generally consisting of employees from different villages. The role is related to age and morality criteria such as honesty, wisdom or the ability to manage daily affairs.

The land in the area of this project belong to the land of the Sissingue village chief.

With the development of the mine, the chief and notables in power may be mere auxiliaries of the modern administration. Thus the areas of their power may be limited.

In contrast, the power of the land chief will be strengthened during the decision making process. The social cohesion of the village is necessary to the harmonious and peaceful development of the project. This impact can be characterized as local, strong and long-term, giving it a major (**Table 4.48**).

Table 4.48 Matrix of negative impacts on socio-economic environment

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Weakening of social power	Reduced power of the village chief and his chiefs could weaken social cohesion necessary for a harmonious and peaceful development of the project	Local	High	Long Term	**Major**

Sacred sites and burial sites

According to the preliminary plan, only the sacred Navigolo site located in the area required for the development of the gold project could disappear. No burial site or object should be destroyed. However, during the work, should other sites hidden in the initial study be found, steps will be taken to mitigate their desecration.

The impact of the project can be characterized as punctual, hard and long, giving it an importance Average (**Table 4.49**).

Table 4.49 Matrix of negative impacts on socio-economic environment

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Construction of the ore processing plant	Disappearance of sacred sites or burial sites	The sacred Navigo site on the area required for the development of the gold project could disappear. The population may fear the desecration and the loss of sacred	On site	High	Long Term	**Average**

Increase in illegal activities

The opening of the mine may have an indirect negative effect through the increase of illegal activities. The impact of the project can be characterized as local, strong and long-term, giving it a major (**Table 4.50**). Mitigation measures should be proposed to tackle this phenomenon before it develops.

Table 4.50 Matrix of negative impacts on socio-economic environment

Identification of impact			**Impact assessment**			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Problems associated with development	The development can have an indirect negative effect through increase of illegal activities	Local	High	Long Term	**Major**

Reactions of people to the project

In addition to the various meetings that took place during the field mission conducted by CECAF International, several informative meetings were held by Perseus Mining Ivory Coast officials to the inform the villagers about the progress of exploration work.

These meetings also allowed the company to assert its will and commitment to continue the development of the Sissingue gold project in a respectful manner for the communities and the environment.

During the public consultation, the concerns raised by the population of the study area were:

- the high cost of living in the village;
- fear of moral depravity due to the influx of immigrants and non-indigenous populations;
- the development of crime (theft, drugs);
- total loss of land for agriculture after mining;
- risks related to potential chemical spills in rivers and soil that could cause impacts on the state of the village environment;
- risk of disease related to the influx of people seeking employment;
- abandonment of farming by young people in favor of work at the mine;
- loss of regular financial gains from land rental;
- the low level of compensation;
- employment given to foreigners;
- destruction of perennial crops;
- destruction of sacred sites because of mining activity;

- the weakening of the family structure and divorces, possibly related to the influx of people;
- the problems of coexistence between indigenous populations and people of diverse backgrounds;
- desecration of sacred sites of the town and the region;
- the loss of ancestral land rights;
- road safety because of the influx of traffic;
- retraining of youth following the the closure of the mine;
- loss of cultural identity.

The wishes of the population are generally the same and relate to employment opportunities and the development of socio-economic infrastructure in their respective villages.

In general, people want the implementation of a community development project with positive social and economic impact on their communities. Note that several of the claims made by those present at the meetings are directly linked to precarious conditions of their village, including lack of social infrastructure.

Despite the drawbacks of such a project on their community and the people, increasing employment, compensation for loss of property and the improvement of local infrastructure are major benefits that are usually perceived by the population as offsetting any negative considerations of the project.

4.11.2 Impacts on the remains

The collected remains revealed the cultural diversity of prehistoric times in the project area significantly contributing to the enrichment of the national archaeological collection.

No particular archaeological sites were discovered in the project development area. Accoriding to the preliminary site plan, some remains such as ceramics fragments were found slightly northeast of the project development area.

The creation of open pits could reveal remains of national interest.

The impact of the project can be characterized as on site, average and medium term, giving it a minor (**Table 4.51**).

Table 4.51 Matrix of negative impacts on the remains

Identification of impact			Impact assessment			
Activity/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Digging of quarries and pits	Destruction of important remains	No particular archaeological sites were discovered in the project development area. Some remains such as ceramics fragments were found northeast of the project development area.	On site	Average	Medium Term	**Minor**

4.12 COMMUNITY HEALTH

Mining operations can indirectly negatively contribute to the spread of several diseases in the project area. Job seekers from various backgrounds would increase the size of the local population and this may cause a deficit in the existing health capacity.

The impact of the project can be characterized as local, high intensity and long-term, giving it a major (**Table 4.52**).

Table 4.52 Matrix of negative impacts on community health

Identification of impact			Impact assessment			
Activity/ Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Problem of development of diseases	Mining operations can inevitably cause negative indirect effects linked to any kind of diseases (STI, HIV / AIDS, diseases related to	Local	High	Long Term	**Major**

4.13 PRODUCTION OF NON MINE WASTE

The operation of the project will generate several types and categories of non-mining waste such as solid household waste, ordinary industrial waste, special industrial waste (including used oil and oil filters) and laboratory waste. This waste, if not managed properly can cause pollution of different environments, including the air, surface and groundwater and soil.

The impact of the Project can be characterized as on site, high and long term, giving it an importance Average (**Table 4.53**).

Table 4.53 Matrix of impacts- Production of non-mine waste

Identification of impact			**Impact assessment**			
Activity/ Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Operation and servicing of the site	Non-mine waster	The various types of waste (solid household, industrial, special industrial and laboratory) to be generated, can pollute the environment, including air by odors, surface and groundwater and soil	On site	High	Long Term	**Average**

4.14 IMPACT MATRIX

Landscape						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Earthworks, mining and tailings storage	Landscape degradation	Permanent damage to the aesthetics of the site making it unattractive and difficult to live.	Local	Low	Long Term	**Average**
Atmospheric Environment in the construction phase						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Movement of vehicles on roads	Dust formation	Timely and localized increase in dust levels can hinder users and increase the risk of accidents	On site	Low	Short Term	**Minor**
Earth works	Dust formation	Localized increase in fine particles that land on the vegetation	On site	Low	Short term	**Minor**
Atmospheric Environment during operational phase						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Ore crushing	Dust formation from fixed sources	Timely increase in dust levels can affect the health of workers crushing station.	On site	Low	Medium term	**Minor**
Combustion ovens	Dust formation from fixed sources	Small-time increase of PM10 dust levels. The particles disperse very rapidly in the atmosphere	On site	Low	Medium term	**Minor**
Working with explosives	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries.	On site	Low	Medium term	**Minor**

Atmospheric Environment during operational phase						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Wind on surface	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries	On site	Low	Medium term	**Minor**
Movement of vehicles on dirt tracks	Dust formation from diffuse sources	Timely and localized increase in dust levels may hinder the users of different tracks and increase the risk of accidents	Local	Average	Medium Term	**Average**
Diesel engines	Production of greenhouse gases	Increasing carbon levels in the atmosphere and other gases (SO_2 et NO_2)	Local	Low	Medium Term	**Minor**
Laboratory analyses	Gas emissions	Increase the amount of gas that would threaten the health of laboratory operators	On site	High	Medium Term	**Minor**
Atmospheric Environment during construction and operational phase						
Identification of cumulative impact			**Cumulative impact assessment**			
Activity/Sources of the impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Adding a third crusher	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Local	Low	Medium Term	**Minor**
Construction of the WWTP	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Local	Low	Short Term	**Minor**
Construction of the airstrip	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Local	Low	Medium Term	**Minor**

Noise and vibrations during operation						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Crushers, processing plant and mining equipment	Continuous noise	Levels above 85 dBA noise can affect hearing ability of workers and the surrounding population	On site	High	Medium Term	**Average**
Work with explosives in the three quarries	Noise and vibrations	Effects on the inhabitants	Local	Average	Medium Term	**Average**
Takeoff and landing of aircraft on the runway	Increased level of noise	Aircraft could increase the noise level at the mine site during takeoff and landing	On site	Average	Medium Term	**Minor**
Aquatic environment during the construction period						
Identification of the impact			**Impact Assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Site preparation and surface blasting	Poor quality of surface water	Increase in silting of river	Local	Average	Short Term	**Minor**
Machine use in site preparation	Poor quality of surface water	Oil spills affecting river quality	On site	Average	Short Term	**Minor**
Site preparation	Poor quality of surface water	Increased organic matter and pathogens (coliform)	Local	Average	Short Term	**Minor**
Aquatic environment during operation						
Identification of the impact			**Impact Assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Clearing the ground for works	Disruption of hydrological regime	Changing the runoff coefficient due to changes in topography and surface conditions that can foster a quicker flow	Local	Average	Long Term	**Average**

Aquatic environment during operation						
Identification of the impact			**Impact Assessment**			
Activities/Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Pumping water to fill the water balance deficit	Disruption of hydrological regime	Changing the flow rate and possibilities of the Bagoé drying up of for extended periods, which may affect the aquatic ecosystem	Local	Average	Medium Term	**Average**
Water discharge from the mine due to heavy rain	Disruption of hydrological regime	Slight modification of stream flow but should not affect the functions of the aquatic ecosystem, especially downstream of the project area	On site	Low	Medium Term	**Minor**
Accidental discharge of effluent following the drilling of a pipe, hose rupture, etc.	Poor quality of surface water	Effluents containing cyanide that reach waterways can have a negative effect on the aquatic ecosystem downstream of the project area	On site	High	Medium Term	**Minor**
Water discharge into the environment following heavy rain	Poor quality of surface water	Potential deterioration of the quality of streams that could affect the functions of the aquatic ecosystem	On site	Low	Medium Term	**Minor**
TSF and other project areas	Poor quality of surface water	Possibility of siltation affecting the functions of the aquatic ecosystem	Local	Average	Medium Term	**Average**
Oxidation of sulfur rock and acid drainage	Poor quality of surface water	Drainages acids formed during oxidation of rocks containing sulfides can generate toxic effluents in the aquatic environment	Local	Low	Medium Term	**Minor**

Aquatic environment during operation						
Identification of the impact			**Impact Assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Domestic effluents and contents of septic tanks	Poor quality of surface water	Increased organic matter and pathogens (coliforms) can contaminate surface water	Local	Average	Medium Term	**Average**
Hydrocarbon leakage into the environment	Poor quality of surface water	The presence of large quantities of hydrocarbons on the site, the use of vehicles and heavy equipment and their maintenance requires special management to prevent their loss to the environment and an introduction into rivers	Local	Average	Medium Term	**Average**
Chemical spills	Poor quality of surface water	The presence of significant amounts of chemicals in rivers. Proper transportation and handling of these chemicals should be taught to officers in charge.	Local	High	Long Term	**Major**
Pumping for potable water	Poor quality and decrease in the amount of groundwater	Pumping rates will be low and consistent with the nature of the aquifers in the project area. No impact should be observed.	Local	Low	Medium Term	**Minor**
Seepage from the tailings	Poor quality and decrease in the amount of groundwater	Water seepage circulating in the groundwater of the regolith and could result in long term contamination of deep groundwater (fracture type) and surface water downstream	Local	High	Long Term	**Major**

Aquatic environment during the operation period						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Seepage of chemical products	Poor quality and decrease in the amount of groundwater	Chemicals penetrated the ground water and long term contamination of ground water (fracture type)	Local	High	Long Term	**Major**

Ecological Environment during construction and operation period						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast).	The development of the project should not cause the destruction of forests or habitat with significant ecological value.	Local	Average	Medium Term	**Minor**
Different mining activities	Pollution (Noise, dust, waste) from the project activities on wildlife	Some groups of species such as fish or birds are populations at higher risk of exposure to pollution generated by the project.	On site	Low	Medium Term	**Minor**
	Holes and pits	The animals could fall and be trapped in the holes or pits dug during the construction phase and operation	Local	Average	Long term	**Average**
Influx of population in the project area	Indirect effects on the ecological environment	Increase in hunting and the chopping down of trees for firewood	Local	Average	Medium Term	**Average**
Takeoff and landing	Risk of accidents by hitting birds or mammals	The risk of accidents can occur on runways by hitting birds or mammals	On site	Average	Medium term	**Minor**

Soil Environment during construction and operation period						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
The various activities of site preparation and the exposure of large areas of land	Soil erosion	Site preparation activities can lead to loss of land, while leaching of fine particles may cause pollution of surface waters	On site	Average	Medium Term	**Minor**
Poor handling or accidental release of hazardous chemicals during transport	Soil erosion	Poor handling or spills of hazardous chemicals and seepage of heavy metals from works such as the TSF or tailings poured could contaminate the soil.	Local	High	Long Term	**Major**
Land use during construction and operation period						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of project works and road construction	Destruction of farms	The development of project works will cause a loss of farming	Local	High	Long Term	**Major**
Positive impacts on the socio-economic environment						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Creation of new jobs	Training and employment	The project will create about 300 direct jobs and many temporary jobs. The training will be at the heart of the project development strategy.	Regional	Average	Medium Term	**Major**

Positive impacts on the socio-economic environment						
Identification of the impact			**Impact assessment**			
Activities/Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Payment of taxes	Royalties	Improving the living conditions of the population through the payment of taxes to the State of Côte d'Ivoire to strengthen the infrastructure of the	Regional	Average	Long term	**Major**
Negative impacts on the socio-economic environment						
Identification of the impact			**Impact assessment**			
Activities/ Source of impact	**Impact Identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of various project works	Displacement of the population in nearby hamlets	Some isolated hamlets on the location of important works would be affected. Any population displacement is considered a very complex process because it requires not only ensure a new home (if necessary) but also continuity of their livelihoods	Local	High	Long Term	**Major**
Development of the gold mine	Massive influx of population	The opening of the mine in the area will attract a number of people looking for work. Any increase in population in villages already inadequate basic infrastructure can enhance the magnitude of the problem. On the other hand, an additional influx of "Foreigners" can increase tension between indigenous peoples, immigrants and non-indigenous.	Local	High	Medium Term	**Average**

Negative impact on the socio-economic environment						
Identification of the impact			**Impact assessment**			
Activities / Sources of impact	**Impact identifid**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Weakening of social power	Reduced power of the village chiefs could weaken social cohesion necessary for a harmonious and peaceful development of the project	Local	High	Long Term	**Major**
Construction of the ore processing plant	Disappearance of sacred sites or burial sites	The sacred Navigo site on the area required for the development of the gold project could disappear. The population may fear the desecration and the loss of sacred sites	On site	High	Long Term	**Average**
Development of the gold mine	Problems associated with	The development can have an indirect negative effect through increase of illegal activities	Local	High	Long Term	**Major**
Negative Impacts on the remains						
Identification of the impact			**Impact Assessment**			
Activities / Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Digging of quarries and pits	Destruction of important remains	No particular archaeological sites were discovered in the project development area. Some remains such as ceramics fragments were found northeast of the project development area.	On site	Average	Medium Term	**Minor**
Negative impact on community health						
Identification of the impact			**Impact Assessment**			
Activities / Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Development of the gold mine	Problem of development of diseases	Mining operations can inevitably cause negative indirect effects linked to any kind of diseases (STI, HIV / AIDS, diseases related to water, etc.)	Local	High	Long Term	**Major**

Impact of the production of non-mining waste						
Identification of the impact			**Impact Assessment**			
Activity/ Source of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Operation and servicing of the site	Non-mine waster	The various types of waste (solid household, industrial, special industrial and laboratory) can pollute the environment, including air by odors, surface and groundwater and soil.	On site	High	Long Term	**Average**

Interactive Impact of the water, soil and crops						
Identification of the impact			**Impact Assessment**			
Activities / Sources of impact	**Impact identified**	**Analysis**	**Scope**	**Intensity**	**Duration**	**Importance**
Operation of the camp and administration	Increased organic matter in surface water, soil infertility, decreased agricultural yields	Domestic wastewater may cause an increase in organic matter in surface water, leading to soil infertility, low permeability of irrigated soils and declining agricultural output	Local	Low	Medium Term	**Minor**

5.0 MITIGATION MEASURES

5.1 INTRODUCTION

This section of the Environmental and Social Impact Assessment report presents the measures envisaged by Perseus Mining Côte d'Ivoire to control, mitigate or possibly offset the damaging consequences of the operation, both during the construction phase and during operation of the facilities.

The environmental protection measures have been classified by area in order to make a direct link with major potential impacts presented in the previous Chapter. The importance of impact was reassessed after the implementation of mitigation measures. An estimate of the cost of these measures is also presented.

Under normal conditions, the negative impacts can be mitigated through the implementation of relatively simple environmental management measures and controlled through regular monitoring.

5.2 IMPACT ON THE LANDSCAPE

The impact of mining on the landscape will be noticeable by local people for many years even after the closure of the mine if certain provisions are not taken. The environment has no ecological, tourist and historical significance. Associated mitigation measures and costs envisaged by the mining company are shown in **Table 5.1** below.

Table 5.1 Mitigation measures for landscape impact

Identification of the impact		
Activities/ Source of	**Impact identified**	**Analysis**
Earthworks, mining and tailings storage	Landscape degradation	Permanent damage to the aesthetics of the site making it unattractive and difficult to live.

Mitigation measures	**Associated costs**
Implementation of a rehabilitation and revegetation program of stripped areas from earthworks.	Part of the rehabilitation (Chapter 7.0) and environmental management (operational costs) budgets
Reduce the number of trees cut down to the minimum required by raising public awareness and mine workers.	Procedure for Environmental Management (Chapter 6.0)

5.3 ATMOSPHERIC ENVIRONMENT

5.3.1 Airborne particulates

5.3.1.1 Mitigation measures during construction

During the construction phase, potential sources of dust will be limited to earthworks activities and the movement of vehicles that transport personnel or construction materials on site. This diffuse source could present more road safety problems than environmental pollution, due to a decrease in visibility on the roads which may increase the risk of accidents. The mitigation measures and associated costs envisaged by the mining company are shown in **Table 5.2** below.

Table 5.2 Mitigation measures for impacts on the atmospheric environment during construction period

Identification of the impact		
Activities/Source of impact	**Impact identified**	**Analysis**
Movement of vehicles on	Dust formation	Timely and localized increase in dust levels can hinder users and increase the risk of accidents
Earth works	Dust formation	Localized increase in fine particles that land on the vegetation

Mitigation measures	**Associated costs**
A tanker evenly disperses water on the roads to keep them sufficiently wet limiting the conditions under which the dust is generated	Part of the environmental management budget
On the project site, the speed of vehicles will be regulated by signs posted in various parts of the site.	Part of the environmental management budget
Strict guidelines will be distributed to subcontractors and vehicle drivers to ensure they do not exceed the speed limit. These instructions are inserted into specific clauses in contracts to subcontractors.	Environmental management procedure
Bare surfaces will be kept to a minimum, especially in work areas. Bare areas will progressively grassed.	Part of the environmental management budget

5.3.1.2 Mitigation measures during the operation phase

Fixed Sources

Of the three stationary sources that generate dust particles, only the ore crusher will require the implementation of mitigation measures that cover environmental pollution and workers' health.

The mitigation measures and associated costs envisaged by the mining company are shown in **Table 5.3**

Table 5.3 Mitigation measures for impact on atmospheric environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Ore crushing	Dust formation from fixed	Timely increase in dust levels can affect the health of workers crushing station.
Combustion ovens	Dust formation from fixed	Small-time increase of PM10 dust levels. The particles disperse very rapidly in the atmosphere

Mitigation measures	**Associated costs**
Masks for protection against dust will be distributed to the workers.	Health and hygiene management procedure. The cost of protective masks is included in the operating budget.
Installation of a chimney at the highest point of the	Part of operations budget

Diffuse Sources

The main diffuse source of dust is the movement of vehicles on laterite roads, which requires the adoption of mitigation measures. The layout of the different roads and ore transport routes was chosen to avoid the village of Sissingue. Associated mitigation measures and costs envisaged by the mining company are shown in **Table 5.4** below.

Table 5.4 Mitigation measures for impact on atmospheric environment during operation

Identification of the impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Movement of vehicles on dirt tracks	Dust formation from diffuse sources	Timely and localized increase in dust levels may hinder the users of different tracks and increase the risk of accidents
Working with explosives	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries.
Wind on surface	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries

Mitigation Measures	**Associated Costs**
Limiting traffic speeds and regular watering of tracks by water tankers. The frequency of watering will depend on weather conditions and tracks attendance.	Part of the environmental management budget.
The use of an explosive system that could reduce the emission of dust. The explosion areas will be minimized and the wind direction will be controlled.	Part of the operational and environmental management budgets
Before the explosion, the public will be informed and increased awareness will be made about it.	Good environmental management procedures.

Bare surfaces are watered regularly during dry periods to prevent dust.	Part of the environmental management budget.

It should be noted that during the operation, quantities of dust (PM10 and total particulates) can be measured to verify the predicted impact level and to monitor the effectiveness of the measures recommended. The determination of the dust levels will be made in sensitive areas, namely the project area and around the village of Sissingue.

5.3.1.3 Mitigation measures for cumulative impacts

Treatment plant

The addition of one (1) crusher in the processing chain to two (2) certainly causes an increase of dust. The spatial influence of the impact, intensity, and duration are minimal compared to the original unit. Therefore, the addition of a crusher in the ore crushing chain does not change the impact. The proposed mitigation measures mainly concern the use of protective masks against the dust for employees working at this position.

WWTP

Work on the construction of the wastewater treatment plant could cause an amount of accumulated dust. These quantities of dust are also minimal compared to those generated on the project sites.

To mitigate this impact, site areas will be regularly watered to reduce atmospheric emissions.

Air strip

Work on the excavation and operation of the runway could also result in a combined amount of dust. These quantities of dust are also minimal compared to those generated on the project sites. The surfaces of this runway will be constantly watered to reduce atmospheric emissions.

The mitigation measures and associated costs are shown in **Table 5.5**below.

Table 5.5 Mitigation measures for cumulative impacts on atmospheric environment

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Adding a third crusher	Increasing the amount of dust on the plant site	Increase in dust levels can harm employees
Construction of the WWTP	Increasing the amount of dust on the plant site	Increase in dust levels can harm employees
Construction of the airstrip	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees

Mitigation Measures	**Associated costs**
Using protective masks against the dust	Part of the environmental management
Surfaces regularly watered to reduce air emissions	Part of the operational and the environment management budget

5.3.2 Atmospheric Emissions

The main atmospheric emissions from mine activities will come from diesel vehicles, carbon regeneration kiln, melting furnaces and the emergency generator and the laboratory. The purchased equipment will be new and emission levels of the engines will comply with international standards.

The impact assessment has determined that the smoke in the laboratory could be very dangerous for the workers and there is a need to implement mitigation measures. For this, extractors provided with flue gas recovery filters are very effective. The mitigation measures and associated costs envisaged by Perseus Mining are listed in **Table 5.6** below.

Table 5.6 Mitigation measures for cumulative impacts on atmospheric environment during operation

<table>
<tr><th colspan="4">Identification of the impact</th></tr>
<tr><th>Activity/Source of impact</th><th>Impact identified</th><th colspan="2">Analysis</th></tr>
<tr><td>Diesel engines</td><td>Production of greenhouse gases</td><td colspan="2">Increasing carbon levels in the atmosphere and other gases (SO_2 et NO_2)</td></tr>
<tr><td>Laboratory analyses</td><td>Gas emissions</td><td colspan="2">Increase the amount of gas that would threaten the health of laboratory operators</td></tr>
<tr><th colspan="3">Mitigation measures</th><th>Associated costs</th></tr>
<tr><td colspan="3">Selection of diesel vehicles using quality products; development of a preventive maintenance program; immediate repair of vehicles and regular review of vehicle breakdowns.</td><td>Operational budget of the project</td></tr>
<tr><td colspan="3">Installation of laboratory extractors equipped with fume recovery filters.</td><td>Operational budget of the project</td></tr>
</table>

5.3.3 Noise and vibrations

The operation of the mine will generate an increase in the noise level on site near the crusher plant and in the surrounding environment particularly due to blasting activities with explosives. These two impacts will require specific mitigation measures presented in **Table 5.7** and **Table 5.8** respectively.

To work with explosives, the maximum emission rate for the sound of explosions measured near the closest receiver will comply with the IFC threshold limits. The maximum 115 dB of can be exceeded by 5% over 12 months without exceeding the absolute limit of 120 dB. Maximum vibration levels measured on the edge of the nearest receiver will be a maximum of 5 mm / s can be exceeded by 5% over 12 months but not exceeding the absolute limit of 10 mm / s.

Note that all roads, including high traffic and ore transport routes, are located far away from residential areas.

Table 5.7 Mitigation measures for noise and vibration impact

Identification of impact			
Activity/Source of impact	**Impact identified**	**Analysis**	
Crushers, processing plant and mining equipment	Continuous noise	Levels above 85 dBA noise can affect hearing ability of workers and the surrounding population	
Mitigation measures			**Associated costs**
Every worker in will receive hearing protection helmets.			About $ 500 for a dozen helmets
Making noise measurements for identification of potential impact. Build sound barriers if necessary to protect the surrounding population.			Part of the environmental management budget.

Table 5.8 Mitigation measures for noise and vibration impact

Identification of impact			
Activity/Source of impact	**Impact identified**	**Analysis**	
Work with explosives in the three quarries	Noise and vibrations	Effects on the inhabitants	
Mitigation measures			**Associated costs**
Using modern techniques with explosives by a competent contractor with experience in the subregion.			Good operational management procedure
To minimize the surprise of detonations on people, the company will ensure that the explosion hours will be communicated in advance to the inhabitants of Sissingue, as well as local residents.			Good operational management procedure
The vibrations generated by blasting with explosives could create cracks in the buildings of the villages mentioned above. Therefore, the buildings structural conditions will be regularly monitored and photos will be taken as supporting evidence.			A camera, a database and a good procedure for environmental management
During each explosion, noise and vibration levels will be measured at about 500 m from the quarry.			US $ 3,000 for the purchase of the unit and good procedure for environmental management

In terms of cumulative impacts related to aircraft noise on the airstrip, hearing protection masks will be distributed to all employees, including those working at or near the airstrip. Moreover, a sound environment management plan will be implemented in the runway area to possibly treat noise complaints (**Table 5.9**).

Table 5.9 Mitigation measures for the cumulative impacts of aircraft noise

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Takeoff and landing of aircraft on the runway	Increased level of noise	Aircraft could increase the noise level at the mine site during takeoff and landing
Mitigation measures		**Associated costs**
Using protective masks against noise		Part of the environmental management budget
Establishment of a complaints management plan related to noise on the runway		Part of the environmental management and operation budget

5.4 AQUATIC ENVIRONMENT

5.4.1 Surface water

5.4.1.1 Mitigation measures during construction

During the construction period and site preparation, accidental discharges of oil and domestic effluents related to the development of the site have been identified as potential sources of impact on the surface water. The mitigation measures and associated costs envisaged are shown in **Table 5.10**,

Table 5.11 and **Table 5.12.**

Table 5.10 Mitigation measures for impacts on the aquatic environment during the construction period

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Site preparation and surface blasting	Poor quality of surface water	Increase in silting of river
Mitigation measures		**Associated costs**
Sedimentation basins will be built at the lowest point of the site of the processing plant and ore storage. The edges of these ponds will be planted with grass or riprapped.		US $ 4000 for the areas located downstream of the treatment plant. The edges of these ponds will be planted with grass or riprapped.

Table 5.11 Mitigation measures for impacts on the aquatic environment during the construction period

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Machine use in site preparation	Poor quality of surface water	Oil spills affecting river quality
Mitigation mesaures	**Associated costs**	
As a safeguard, the company will introduce requirements to protect and respect the environment in the contracts of subcontractors. It will be stipulated for example to use well-maintained vehicles, storing hydrocarbons on appropriate retention areas or to clean up a site Accidental pollution caused due to a breach of covenants.	Good environmental and operational management procedure.	

Table 5.12 Mitigation measures for impacts on the aquatic environment during the construction period

Identification of impact		
Activity/Sources of impact	**Impact identified**	**Analysis**
Site preparation	Poor quality of surface water	Increased organic matter and pathogens (coliform)
Mitigation measures	**Associated costs**	
Domestic effluents from toilets will be drained into septic tanks.	Around US$ 1 000	

5.4.1.2 Hydrological mitigation measures

Changes in the topography

Changes in topography and the influence of different works of Sissingue gold project may alter the surface conditions of the sub watershed tributary of the Bagoé on the site (**Table 5.13**).

Table 5.13 Mitigation measures for impacts on the aquatic environment during operations

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Clearing the ground for works	Disruption of hydrological regime	Changing the runoff coefficient due to changes in topography and surface conditions that can foster a quicker flow
Mitigation measures	**Associated costs**	
The design and construction of the project works include the installation of a network of diversion ditches, drainage channels, sedimentation basins, culverts, etc. to minimize the negative effects of increased runoff coefficient.	Included in the cost of design and project investment capital	

Water supply for the process

In the Project area, the surface water pumping activities correspond to a reduction in the total flow of the Bagoé river. This river is not used to support the local population through drinking water or watering fields. Mitigation measures will minimize the impact on the ecosystem of low water (**Table 5.14**).

Should it be necessary to use water from the Bagoé, the maximum speed pump should be significantly less than those in Kouto stations and Papara: 33.11m3 / s and 42.76 m3 / s respectively.

Table 5.14 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Pumping water to fill the water balance deficit	Disruption of hydrological regime	Changing the flow rate and the possibility of the Bagoé drying up of for extended periods, which may affect the aquatic ecosystem
Mitigation Measures	**Associated costs**	
Pumping water from the Bagoé will be restricted to rainy periods. When pumping water from the side of the left bank of the Bagoé owned by the Republic of Côte d'Ivoire, the company will send a request to the administrative authorities (Department of Hydraulics and Water Resources Management).	Good environmental and operational management procedures	

Discharge of water from the mine

Discharge of water from the mine into the environment in case of heavy rains could slightly alter stream flow. This should not affect the normal functioning of the aquatic ecosystem downstream of the project area (Table 5.15).

Table 5.15 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Water discharge from the mine due to heavy rain	Disruption of hydrological regime	Slight modification of stream flow but should not affect the functions of the aquatic ecosystem, especially downstream of the project area

Mitigation Measures	**Associated costs**
Conserve this water and reuse it to water the access road and the tracks inside the mine.	Operational budget and part of the environmental management budget

5.4.1.3 Mitigation measures related to issues of quality

Mitigation measures against accidental spills or effluent solutions

At Sissingue, the ore treatment process will operate in a closed circuit and all liquid waste will be recycled and reused. The water balance is negative (or deficit) and only spills could be the cause of pollution of the aquatic environment. Solutions containing cyanide could be accidentally discharged into the environment after the piercing of a pipe, hose rupture, leakage of a pump, overflow of a leach tank, etc. Associated mitigation measures and costs envisaged by the mining company are shown in **Table 5.17**.

Discharge of water from the mine

All pumping will be used as the power source for the ore treatment process or for watering the tracks (to reduce dust formation) (**Table 5.18**). Nothing should be discharged into streams of the Project area except during heavy rains. However, specific mitigation measures will be put in place. The quality of this pumping should be monitored regularly, particularly in regard to the concentrations of arsenic. Surface water standards will be respected (TSS <50 mg / l As <0.1 mg / l).

TSF and other works

One possible consequence of the runoff effect on the TSF and other works of the project is the transport of fine particles of soil that can cause pollution of surface waters by increasing concentrations of suspended solids. Specific mitigation measures will be implemented at the design of the project. Regular monitoring of the quality of surface waters will verify the effectiveness of these measures (**Table 5.16**).

Table 5.17 Mitigation measures for impacts on the aquatic environment during operation

<table>
<tr><th colspan="4">Identification of impact</th></tr>
<tr><th>Activity/Source of impact</th><th>Impact</th><th colspan="2">Analysis</th></tr>
<tr><td>Accidental discharge of effluent following the drilling of a pipe, hose</td><td>Poor quality of surface water</td><td colspan="2">Effluents containing cyanide that reach waterways can have a negative effect on the aquatic ecosystem downstream of the project area</td></tr>
<tr><th colspan="3">Mitigation Measures</th><th>Associated costs</th></tr>
<tr><td colspan="3">The majority of solutions containing cyanides are in the processing plant. All tanks, pipes or pumps in contact with cyanides include a retention area can recover accidental leaks.</td><td>Included in the design cost and the project's investment capital</td></tr>
<tr><td colspan="3">Regular inspections of pumps, pipes, tailings dam and the seepage collection pond will be conducted by the department in charge of the process</td><td>Good operational management procedure (operational costs)</td></tr>
<tr><td colspan="3">The quality of surface water downstream of the plant and the TSF will be monitored regularly by the environment department. Monitoring will include an analysis of pH, conductivity, cyanide and heavy metals.</td><td>Part of the environmental management budget (Chapter 6.0)</td></tr>
<tr><td colspan="3">Accidental spills with cyanides, calcium hypochlorite will be available to detoxify the area that was accidentally contaminated. Calcium hypochlorite can be dispersed manually on cyanide solutions which have escaped from the circuit. Cyanides are oxidized to form a non-toxic cyanate compound and finally carbonates and ammonia.</td><td>US $ 1000 for a decontamination kit and good procedure for environmental management</td></tr>
</table>

Table 5.18 Mitigation measures for impacts on the aquatic environment during operation

<table>
<tr><th colspan="4">Identification of impact</th></tr>
<tr><th>Activity/Source of impact</th><th>Impact identified</th><th colspan="2">Analysis</th></tr>
<tr><td>Water discharge into the environment in case of heavy rain</td><td>Poor quality of surface water</td><td colspan="2">Potential deterioration of the quality of streams that could affect the functions of the aquatic ecosystem</td></tr>
<tr><th colspan="3">Mitigation measures</th><th>Associated costs</th></tr>
<tr><td colspan="3">Water discharges from the mine will be done in a controlled manner. Their quality will be continuously monitored in case the drainage water should be rejected</td><td>Part of the environmental management budget</td></tr>
</table>

Table 5.19 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
TSF and other project areas	Poor quality of surface water	Possibility of siltation affecting the functions of the aquatic ecosystem

Mitigation Measures	Associated costs
Runoff draining of TSF and processing plant where the ore is stored, will be directed into the environment via sedimentation basins.	Included in the design cost and the project's investment capital
Early rehabilitation and revegetation sites and exposed areas will be systematically considered.	Good operational management procedure (operational costs)
The quality of surface water at the basins will be monitored regularly by the environment department.	Part of the environmental management budget (Chapter 6.0)

Oxidation of sulfur rock and acid drainage formation

Testing revealed no favorable potential of acid formation. Thus, it is possible to say that the risk of seeing an acid drainage problem is practically nonexistent.

However, specific mitigation measures will be in place (**Table 5.20**).

Table 5.20 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Sources of impact	**Impact identified**	**Analysis**
Oxidation of sulfur rock and acid drainage	Poor quality of surface water	Drainages acids formed during oxidation of rocks containing sulfides can generate toxic effluents in the aquatic environment

Mitigation measures	Associated costs
During operation, the acid potential tests will be performed regularly on samples of tailings and ore during their extraction. If a problem occurred it is still possible to take appropriate measures such as encapsulation of reactive material.	Part of the environmental management budget

Domestic Effluent

Domestic effluents from the camp will be collected and drained into septic tanks.

For some remote sites and the various administrative and technical buildings, it will also be necessary to treat these septic effluents built to international standards.

The contents of septic tanks will be removed correctly to avoid environmental pollution.

The mitigation measures and associated costs envisaged by the mining company are shown in

Table 5.21.

Table 5.21: Mitigation measures for impacts on the aquatic environment during operation

<table>
<tr><th colspan="4">Identification of impact</th></tr>
<tr><th>Activity/Source of impact</th><th>Impact identified</th><th colspan="2">Analysis</th></tr>
<tr><td>Domestic effluents and contents of septic tanks</td><td>Poor quality of surface water</td><td colspan="2">Increased organic matter and pathogens (coliforms) can contaminate surface water</td></tr>
<tr><th colspan="3">Mitigation measures</th><th>Associated costs</th></tr>
<tr><td colspan="3">Domestic effluents from camp and other sites’ toilets will be drained in septic tanks.</td><td>Around US$ 15 000</td></tr>
<tr><td colspan="3">When septic tanks are filled mining company Perseus Mining will contact a company responsible for the management of waste water disposal according to Ivorian procedure.</td><td>Part of the environmental management budget</td></tr>
</table>

Loss of hydrocarbons and chemical spills

Hydrocarbons could be released into the environment, following a technical failure of a machine or from a tank during a product transfer.

Chemical spills due to poor handling or because of an accident during transport may affect water quality.

The mitigation measures and associated costs envisaged by Perseus Mining Ivory Coast are shown in **Table 5.22**.

Table 5.22 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Hydrocarbon leakage into the environment	Poor quality of surface water	The presence of large quantities of hydrocarbons on the site, the use of vehicles and heavy equipment and their maintenance requires special management to prevent their loss to the environment and an introduction into rivers
Chemical spills	Poor quality of surface water	The presence of significant amounts of chemicals in rivers. A good convenient transportation and handling of these chemicals should be taught to officers committed to the task
Mitigation measures		**Associated costs**
Each tank containing hydrocarbons will be built on a concrete containment area that will hold the volume of at least one tank in case of breakage.		Included in the cost of design and project investment capital. This measure will also be imposed on subcontractors.
The drums containing oils will be stored on an impervious area.		Included in the cost of design and project investment capital.
The workshops will be constructed on an impervious surface for directing all losses to a recovery pit leading to a hydrocarbon separator. The fat accumulated in these systems will be eliminated by the supplier of petroleum products in an appropriate site.		Included in the cost of design and project investment capital.
As a safeguard, the company introduces requirements for the protection and respect of the environment in the contracts of subcontractors.		Good environmental and operational management process.
The good practice of transport and handling of these chemicals should be taught to officers committed to the task (transport conditions, unloading and storage). Effective and immediate cleaning of spills. Transporting chemicals only during the day.		Good environmental and operational management process.

5.4.2 Groundwater

5.4.2.1 Potential impacts due to use of ground water

The drinking water needs for the staff of the mine led Perseus Mining in search of water of sufficient quality and quantity, for instance wells could be dug and equipped with electric pumps.

Thus, the excessive pumping of water would cause the lowering of the water table.

The mitigation measures and associated costs envisaged by the mining company are shown in

Table 5.23.

Table 5.23 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Pumping for drinking water	Poor quality and decrease in the amount of groundwater	Pumping rates will be low and consistent with the nature of the aquifers in the project area. No impact should be observed.
Mitigation Measures		**Associated costs**
Install an electric pump whose pumping rate will not be higher than the drilling. That is to say, an adequate volume of good quality water according to the operating license.		Investment budget

5.4.2.2 Potential impacts due to seepage from the tailings or following the accidental spill of chemicals

The quality of the groundwater could be altered by leaching of heavy metals from the tailings or following the accidental release of chemicals during transport and poor handling. Without the planned recovery system, there could be long-term contamination of deep aquifers (fracture type) and surface water downstream.

The mitigation measures and associated costs envisaged by the mining company are shown in

Table 5.24.

Table 5.24 Mitigation measures for impacts on the aquatic environment during operation

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Seepage from the tailings	Poor quality and decrease in the amount of groundwater	Water seepage circulating in the groundwater of the regolith and could result in long term contamination of deep groundwater (fracture type) and surface water downstream
Seepage of chemical products	Poor quality and decrease in the amount of groundwater	Chemicals penetrated the ground water and long term contamination of ground water (fracture type)
Mitigation measures		**Associated costs**
A recovery system filtering water will be installed at the base of the dam. It will consist of a trench about three meters deep and 5 meters wide which will aim to collect seepage at the interface. Such seepage of water will be collected in a small pond built downstream of the dam, and then pumped to the tailings or to the ore processing plant to be used in the process.		Included in the cost of design and the investment capital of the tailings facility.
An observation site with two wells will be built downstream of the TSF. A shallow well to detect possible pollution from filtering water and deeper wells to monitor potential changes in groundwater quality in depth. Samples will be taken regularly for a determination of parameters such as pH, conductivity, cyanides and heavy metals (sodium, calcium, potassium, magnesium, chloride).		Part of the environmental management budget
A good practice of transport and handling of these chemicals should be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effective and immediate cleaning should be carried out. Transporting chemicals the day only.		Good environmental and operational management procedure.

5.5 MITIGATION MEASURES ON ECOLOGICAL ENVIRONMENT

5.5.1 Location of the works

In the context of this project, construction should at no time cause massive destruction of forests, of fragile habitats or areas with significant ecological value.

This impact on the fragmentation, destruction or loss of habitats of rare Ivorian species (Detarium microcarpum family Caesalpiniaceae and Uvaria tortilis family Annonaceae (see Map 6) of Chapter Description Initial state)), although of minor importance in the context of the project area, will receive special attention from the company offering Mitigation measures on loss of vegetation **Table 5.25**

Table 5.25 Mitigation measures for impacts on the ecological environment during construction and operation period

Identification of impact		
Activity/Source of impact	**Impact identified**	**Analysis**
Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast).	The development of the project should not cause the destruction of forests or habitat with significant ecological value.
Mitigation measures		**Associated costs**
Deforestation sites will be selective and gradual.		Good environmental and operational management procedure.
Before any surface preparation work, the topsoil will be identified and recovered to be used for rehabilitation purposes.		Good environmental and operational management procedure.
Sites rehabilitation activities will be initiated from the beginning of operations and will include the replacement of rare species.		The preliminary program and the costs of the mine rehabilitation are presented in Chapter 7.0.

5.5.2 Impact of the operation on fish and wildlife

The various mining and ore processing activities will firstly cause pollution from noise, dust or chemical spills and will also create risk from water bodies containing cyanides. These activities may be responsible for local changes in the composition of certain aquatic and terrestrial species.

Also, at the end of mining operations, some left holes could also create negative effects on wildlife.

Measures to limit noise, dust formation or effluent discharges containing cyanides, are presented in the previous sections. These measures will contribute positively to the reduction of impacts on wildlife.

The project area is not an ecologically rich area or bird migration path, therefore the impact of pollution created by the operations on wildlife is considered minor (**Table 5.27**).

5.5.3 Indirect Effects of the Project

A mining project developed in a rural area such as that of Sissingue can have significant indirect effects on the ecological environment.

Indeed, the population of the surrounding areas may increase significantly with the likely increase in hunting and cutting down of trees for firewood. However the actual impact on these resources is already significant as revealed by the initial study of area.

Measures will be proposed to offset the Average size impact (**Table 5.26**)

Table 5.27 Mitigation measures for impacts on the ecological environment during construction and operation period

Identification of the impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Different mining activities	Pollution (Noise, dust, waste) from project	Some groups of species such as fish or birds are populations at higher risk of exposure to pollution generated by the project.
	Holes and pits	The animals could fall and be trapped in the holes or pits dug during the construction phase and operation
Mitigation measures		**Associated costs**
Measures to limit noise, dust formation or effluent discharges containing cyanides, are presented in the previous sections. These measures will contribute positively to the reduction of impacts on wildlife.		See respective tables
All holes and ditches will be closed gradually to mine closure. The trenches of the working faces will be inclined to allow the animals to get out.		Operational procedure

Table 5.28 Mitigation measures for impacts on the ecological environment during construction and operation period

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Influx of population in the project area	Indirect effects on the ecological environment	Increase in hunting and the chopping down of trees for firewood
Mitigation measures		**Associated costs**
The inclusion in contracts of employees and subcontractors of a clause prohibiting hunting on the entire license area. On site monitoring of hunting will be performed by employees who travel frequently on different tracks in the area.		Good environmental and operational management procedure.
The display in various locations in the future posters wealth of animal and plant species considered "rare" or vulnerable. The environmental training course, which will be provided to all employees, include a module "Conservation of fauna and flora"		Good environmental and operational management procedure

The presence of wildlife at the airstrip can interfere with operations and therefore represent a potential security risk. There is not a large amount of large mammals in the study area, therefore only small mammals and birds pose a risk during takeoff and landing of aircraft on the mine.

To reduce the impacts between wildlife and aircraft on the runway, it should be noted that the area will be fenced and a plan will be developed to secure the activities on the airstrip (**Table 5.29**).

Table 5.29 Mitigation measures for the impact of aircraft on wildlife

Identification of impact			
Activity/Source of impact	**Impact identified**	**Analysis**	
Takeoff and landing	Risk of accidents by hitting birds or mammals	The risk of accidents can occur on runways by hitting birds or mammals	
Mitigation Measures			**Associated costs**
Fully fenced mining area			Part of the environmental management budget.
Setting up a barrier plan			Part of the operational and the environment management budget.

5.6 SOIL ENVIRONMENT

5.6.1 Soil conservation measures

In order to limit erosion soil conservation measures will be included in the conception of the project and adopted during its construction. These measures are proposed in

Table 5.30

Table 5.30 Mitigation measures for the impact of soil environment during construction and operation periods

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
The various activities of site preparation and the exposure of large areas of land	Soil erosion	Site preparation activities can lead to loss of land, while leaching of fine particles may cause pollution of surface waters
Mitigation Measures		**Associated costs**
Limit deforestation and surface blasting to the minimum required.		Good environmental and operational management
Apply appropriate management of natural flows and isolate the bare areas such as quarry, TSF or ore storage area by the construction of runoff diversion ditches. In addition, runoff water will be discharged into the environment.		Included in the design cost and the investment capital of the project works.
Early revegetation of sites and use of natural obstacles across slopes to retain soil, or if necessary, anti erosion mat on certain parts are considered critical.		Included in the design cost and the investment capital of the project works.
Regular monitoring of the effectiveness of measures and techniques adopted by visual inspection and determination of suspended solids in surface water during the wet season.		Part of the environmental management budget.

5.6.2 Potential impact related to soil contamination

In case of accidental spills of hazardous chemicals on the ground, the mining company is committed to quickly rehabilitating the affected area. In most cases, a good strategy for managing hazardous chemicals, including cyanide, will be implemented in accordance with cyanide management standards during transport and handling. This method will also be applied to hydrocarbons and their derivatives.

The mitigation measures proposed by the company and the associated costs are described in **Error! Not a valid bookmark self-reference.**Table 5.31

Table 5.31 Mitigation measures for impact of soil environment during construction and operating period

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Poor handling or accidental release of hazardous chemicals during transport	Soil erosion	Poor handling or spills of hazardous chemicals and seepage of heavy metals from works such as the TSF or Waste Rock Dump could contaminate the soil.
Mitigation measures		**Associated costs**
Good practice of handling these dangerous chemicals must be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effectively and immediately cleaned. Cyanide management should meet international standards standards.		Environmental management process and part of the environmental management budget.

5.6.3 Impacts on agriculture and farm losses

The total land area of the various works of the Project will be approximately 560.48 hectares including security perimeters. This does not include the power line.

The company's operations have a major direct and indirect negative impact on agricultural activities in the project area. Thus, it will be necessary to pay compensation to people who will be affected by the loss of their fields and propose mitigation measures.

The compensation paid shall fulfill the requirements of the Ivorian legislation, Mining Code, Article 107. This states that for an "occupation for a period exceeding five years or land become unsuitable for cultivation 'compensation (C) CFA francs will be made according to the following formula:

$$C = (10 \times R) + (P \times H)$$

R = Annual revenue of the plot ; P = Average price of acquisition per hectare ; H = hectares.

The mitigation measures and associated costs envisaged by the mining company are shown in **Table 5.32**.

Table 5.32 Mitigation measures for agriculture and farm losses during construction and operating period

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Development of project works and road construction	Destruction of farms	The development of project works will cause a loss of farming
Mitigation Measures		**Associated costs**
Farmers with fields and crops and the landowners affected by the project activities will be financially compensated according to regulations. An accurate assessment of fields and crops will be carried out during the construction period.		Estimated Project Budget
Prior to construction, the area and the influence of the works must be accurately known to avoid massively destroy crops.		Good environmental management and operational procedure

5.7 MITIGATION MEASURES ON THE INTERACTIVE IMPACT OF WATER, SOIL AND LAND

Wastewater from the administration and camp can be divided into two groups: domestic sewerage and rainwater.

Domestic effluents or waste from the camp and administration comes from the cafeteria, restrooms, locker rooms offices and vehicle washing points. These domestic effluents have huge environmental risks. Untreated, they can contaminate surface water including an increase of the organic matter and pathogens (coliform). The discharge of domestic effluents also has a potential for cultivated soils, crops, farmers, and also for consumers. These effluents usually contain a significant amount of micropollutants such as pharmaceuticals and hormones excreted in urine. To this is added large amounts of salts whose accumulation in fertilized soils can lead to salinisation or even sodisation. Excess levels of some ions, such as sodium (Na +) and chloride (Cl-), cause toxicity or deficiency of some nutrients in plants. The negative effects of high soil salinity will cause stunted growth caused by the inhibition of germination, which could cause lower agricultural yields. Unwanted components of gray water such as oils and fats and surfactants in the long-term can lead to a low permeability of soils irrigated with adverse consequences on agricultural productivity and sustainability of the environment. These effluents will be drained through a sewer system to the treatment plant and undergo several processing steps to meet the discharge standards.

Rainwater will be drained in the open. The drainage water from the unpolluted areas will be routed directly to the drains. Moreover, this runoff will be drained where possible so as to minimize runoff into the mine infrastructure. To reduce the issue of soil erosion, all other surfaces will be grassed (**Table 5.33**).

Table 5.33 Mitigation measures for interactive impact of water, soil and land

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Operation of the camp and administration	Increased organic matter in surface water, soil infertility, decreased agricultural yields	Domestic wastewater may cause an increase in organic matter in surface water, leading to soil infertility, low permeability of irrigated soils and declining agricultural output
Mitigation measures		**Associated cost**
These effluents will be drained through a sewer system to the treatment plant and undergo several processing steps to meet the discharge standards.		Good environmental and operational management
Surfaces will be grassed where possible to reduce erosion		Good environmental and operational management

5.8 MITIGATION MEASURES FOR HUMAN ENVIRONMENT

5.8.1 Strengthening the positive socio-economic impacts of the Project

The positive impacts of the project will focus primarily on the economic benefits that will, in the short term and long term, have positive effects on the social environment, including improvements in infrastructures and services that may result from the revenue growth for the region.

On the regional and national level, the project will have positive impacts on employment, training, payment of rent, allowances and taxes, purchase of manufactured goods and services or sold in the national territory and finally the quantity of gold produced, which should increase the official production of the Ivory Coast.

As with any mining project, the development of the Sissingue gold project will have positive and negative impacts on socio-economic aspects of the region. However, the positives should greatly outweigh the negatives. The impacts of major importance must be strengthened through the establishment of consultation and a regular and effective dialogue between all political, social and economic parties (**Table 5.34** and **Table 5.35**).

Table 5.34 Measures for positive impact on socio-economic environment

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Creation of new jobs	Training and employment	The project will create about 300 direct jobs and many temporary jobs. The training will be at the heart of the project development strategy.
Measures		**Associated Costs**
Young people from the project area and the region will be used in priority after a selection based on the general suitability of the person.		Good environmental and operational management procedure.

Table 5.35 Measures for positive impact on socio-economic environment

Identification of impact		
Activity/ Sources of impact	**Impact identified**	**Analysis**
Payment of taxes	Royalties	Improving the living conditions of the population through the payment of taxes to the State of Côte d'Ivoire to strengthen the infrastructure of the region.
Measures		**Associated costs**
This impact will be strengthened through a process of consultation between all the political, social and economic players. The company will comply with the		TBD.

5.8.2 Population displacement

Perseus Mining Ivory Coast has understood that only a participatory approach will lead to equitable development of the project. Population displacement, even on a small scale, is considered a very complex process that is carried out in well-defined stages. Maintaining a continuous dialogue with the affected parties and the implementation of concrete actions are the only way to gain their trust.

Past experience has shown that population displacement can only succeed when if the displaced are offered better living conditions. Perseus Mining Ivory Coast will prepare a travel plan (physical and / or economic) as soon as approvals of farms will be obtained (**Table 5.36**).

Table 5.36 Mitigation measures for negative impacts on the socio-economic environment

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Development of various project works	Displacement of the population in nearby hamlets	Some isolated hamlets on the location of important works would be affected. Any population displacement is considered a very complex process because it requires not only ensure a new home (if necessary) but also continuity of their livelihoods
Mitigation Measures		**Associated costs**
A displacement plan (physical and / or economic) will be prepared by a specialist as soon as the operating authorizations will be obtained. A participatory process that will be completed and the implementation will be made by Environment Staff Perseus Mining Ivory Coast. An arbitration committee will be established to resolve conflicts that might arise.		An amount of US $ 60,000 has been provided for this purpose.
Displaced persons who have received monetary compensation for their loss of income will be encouraged to participate in training programs for the development of alternative projects and training investment.		An amount of US $ 30,000 has been provided for this purpose

5.8.3 Problems relating to potential migration and population growth

Mining operations are generally accompanied by large influx of people seeking employment. In an area where the infrastructure is poor, such migration may have negative socio-economic and environmental impacts.

The beginning of the construction period will increase the number of people from the department or elsewhere, to settle in the surrounding villages to seek employment at the mine. Some of them will remain there for the duration of the project.

Any increase in population in the villages, which already have inadequate basic infrastructure may increase the magnitude of the problem. Furthermore, an additional influx of 'foreigners' can cause tensions between indigenous peoples and non-indigenous immigrants.

It will not be the responsibility nor Perseus Mining Coast Ivory to control the potential migration flows within the project area. However, mitigation measures as proposed below (**Table 5.37**) will be in place to minimize any potential incident but especially for preventive purposes. All parties concerned should be involved in this process.

Table 5.37 Mitigation measures for negative impacts on the socio-economic environment

<table>
<tr><th colspan="3">Identification of impact</th></tr>
<tr><th>Activity/ Source of impact</th><th>Impact identified</th><th>Analysis</th></tr>
<tr><td>Development of the gold mine</td><td>Massive influx of population</td><td>The opening of the mine in the area will attract a number of people looking for work. Any increase in population in villages with already inadequate basic infrastructure can enhance the magnitude of the problem. On the other hand, an additional influx of “foreigners" can increase tension between indigenous peoples, immigrants and non-</td></tr>
<tr><th colspan="2">Mitigation Measures</th><th>Associated costs</th></tr>
<tr><td colspan="2">As a social partner, the company is committed to maintaining dialogue and contact with government and traditional authorities, in order to monitor, prevent and possibly propose solutions with a view to joint development with communities. For example, it is important to ensure that the number of jobs that could be generated is shared with local officials and populations of villages in the project area and the sub-prefecture of Kanakono. This should help avoid overly ambitious expectations among the population and may affect immigration in the villages in the project area and at the sub-prefecture of Kanakono.</td><td>Good environmental and operational management procedure.</td></tr>
<tr><td colspan="2">One of the most sensitive infrastructures is drinking water. Therefore, Occidental Gold is committed to building an enhanced village water system (HVA) to increase the current capacity to supply Sissingue.</td><td>Study cost of US$ 65 000</td></tr>
</table>

5.8.4 Social Organisation

The project will be developed in an environment where indigenous peoples have often, rightly or wrongly, felt that the administration favours immigrants and other foreigners. Carefully managing decisions involves creating a participatory framework that recognizes the social organization of the region.

Moreover, the land of the area of this gold project belongs to the land of village chief Sissingue.

The land chief and his chiefs may be mere auxiliaries of modern administration with limited power. Their local recognition is needed to strengthen their authority in their respective communities and assume their function of social cohesion.

Mitigation measures are proposed in **Table 5.38** below.

Table 5.38 Mitigation measures for negative impact on the socio-economic environment

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Development of the gold mine	Weakening of social power	Reduced power of the village chief and his chiefs could weaken social cohesion necessary for a harmonious and peaceful development of the project
Mitigation Measures		**Associated costs**
For the consultative process to be effective, the rule of Sissingue village leader will be acknowledged. Also local recognition of the land chief is needed to strengthen social cohesion. Any decision must be co-operative.		Good environmental and operational management procedure.

5.8.5 Sacred sites and burial sites

According to the preliminary plan, only the sacred Navigolo site located in the area required for the development of the gold project could disappear. No burial site or object should be destroyed. However, during the work, should other sites hidden in the initial study be found, steps will be taken to mitigate their desecration (**Table 5.39**).

Table 5.39 Mitigation measures for negative impact on the socio-economic environment

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Construction of the ore processing plant	Disappearance of sacred sites or burial sites	The sacred Navigo site on the area required for the development of the gold project could disappear. The population may fear the desecration and the loss of sacred sites
Mitigation Measures		**Associated costs**
Concerned villagers may participate in the implementation and monitoring of site protection measures and ensure, wherever possible, access to the site at all times.		Good environmental and operational management procedure.
Moving the sacred Navigo site on the area required for the development of the gold project		An amount of US $ 3,000 was provisioned for this purpose.

5.8.6 Community Relations

Perseus Mining Ivory Coast is aware of the importance of maintaining a dialogue and good relations with local populations and authorities. This task will be a priority of the environmental manager who will be employed at the beginning of the construction period.

Information meetings will be organized regularly with traditional authorities, representatives of government services, people, professional groups, and women's representatives to ensure good communication and cooperation between the different parties. A standing advisory committee will be established for this purpose with a representative of all parties concerned.

5.8.7 Problems associated with the development

Table 5.40 Mitigation measures for negative socio-economic impact

Identification of impact			
Activity/ Source of impact	**Impact identified**		**Analysis**
Development of the gold mine	Problems associated with development		The development can have an indirect negative effect through increase of illegal activities
Mitigation Measures			**Associated costs**
Continuous dialogue with the social partners and information from mine employees and local populations.			Good environmental and operational management procedure.

5.8.8 Mitigation Measures for the negative impact on the remains

The collected remains revealed a cultural diversity of prehistoric times in the project area, which significantly contributes to the enrichment of the national archaeological collection. If during the excavation of the open pits and earthworks, some remains of national or international interest are discovered, appropriate measures will be taken for their protection (**Table 5.41**).

Table 5.41 Mitigation measures for negative impact on remains.

Identification of impact		
Activity/ Sources of impact	**Impact identified**	**Analysis**
Digging of quarries and pits	Destruction of important remains	No particular archaeological sites were discovered in the project development area. Some remains such as ceramics fragments were found northeast of the project development area.
Mitigation Measures		**Associated costs**
A specialist of the Institute of Arts and Archaeology of Abidjan will be contacted for extracting remains .question.		An amount of US $ 7,000 was provisioned for this purpose.

5.9 COMMUNITY HEALTH

Mining operations can inevitably cause negative impact linked to any kind of diseases in the project area. Job seekers from various backgrounds would increase the size of the local population and this may cause a deficit in the existing health capacity.

The mitigation measures and associated costs envisaged by the mining company are shown in **Table 5.42**.

Table 5.42 Mitigation measures for negative impacts on community health

Identification of impact		
Activity/ Source of impact	**Impact identified**	**Analysis**
Development of the gold mine	Problem of development of diseases	Mining operations can inevitably cause negative indirect effects linked to all sorts of diseases
Mitigation Measures		**Associated costs**
Perseus Mining will carry out educational and awareness campaigns for employees and		Good operational management and Social Development procedure.
Health monitoring program and medical clinic for employees on site.		

Food hygiene inspections (eg practices and food handling equipment)	Operating budget of monitoring health

5.10 PRODUCTION OF NON-MINING WASTE

5.10.1 Introduction and basic principles

At this stage of the project, it is difficult to quantify the volumes of non-mining waste. Waste management will be done in accordance with the legislation in force, including nº96-766 Act of October 3, 1996, with the environmental code.

The major waste management principles to be adopted by Perseus Mining Côte d'Ivoire:

- regularly updating the waste management plan;
- minimizing waste generation at all levels;
- sorting and recycling waste;
- eliminating waste that cannot be avoided by the most appropriate and economically acceptable method;
- seeking collaboration with other industry operators;
- ensuring that contractors have been informed of their waste management responsibility.

5.10.2 Classification and waste management

An initial inventory of the different categories and types of waste, ranking and modes of elimination are presented in **Table 5.43**.

From the beginning of the construction period, Perseus Mining Ivory Coast will prepare a waste management plan that includes procedures for collection, quantification and disposal by waste type.

Table 5.43 Mitigation measures for impact of non-mining waste

<table>
<tr><th colspan="3">Identification of impact</th></tr>
<tr><th>Activity/ Source of impact</th><th>Impact identified</th><th>Analysis</th></tr>
<tr><td>Operation and servicing of the site</td><td>Non-mining waste</td><td>The various types of waste (solid household, industrial, special industrial and laboratory) generated can pollute the environment, including the air, surface- and groundwater and soil.</td></tr>
<tr><th colspan="2">Mitigation measures</th><th>Associated costs</th></tr>
<tr><td colspan="2">Solid household waste

This type of waste will be produced by the administrative and technical offices, canteen and households.

This waste will be collected on site and transported to a landfill that will likely be built in the TSF or low permeability site. Within the structure, trenches are opened, filled and covered with inert material, in this case of non-mineralized rock. Stored materials are compacted or burned to prevent dispersal by wind.</td><td>Included in the operational costs of the respective departments.</td></tr>
<tr><td colspan="2">Ordinary industrial waste

This class of waste mainly include tires, metal parts, pipes, screens and other used equipment and materials from the processing unit and packaging waste to non-toxic products (plastics, paper, cardboard).

If recycling processes cannot be found locally and at an economically acceptable time, this category of waste will also be sent to the local landfill, in the same way as solid household waste. Often used tires and metal parts can be resold.</td><td>Included in the operational costs of the respective departments</td></tr>
<tr><td colspan="2">Used oil and oil filters as hazardous industrial waste (HIW)

Drain oils will be produced at the processing unit and in the various workshops and systematically collected and disposed of by the contractor and supplier of petroleum products to a recycling process.

Oil filters are drained and transported to landfill.</td><td>Included in the operational costs of the respective departments.</td></tr>
</table>

Table 5.44 Mitigation measures for impact of non-mining waste (continued)

<table>
<tr><th colspan="3">Identification of impact</th></tr>
<tr><th>Activity/ Sources of impact</th><th>Impact identified</th><th>Analysis</th></tr>
<tr><td>Operation and servicing of the site</td><td>Non-mining waste</td><td>The various types of waste (solid household, industrial, special industrial and laboratory) to be generated, can pollute the environment, including air, surface- and groundwater and soil.</td></tr>
<tr><th colspan="2">Mitigation Measures</th><th>Associated costs</th></tr>
<tr><td colspan="2">Other HIW
Special or hazardous industrial waste includes batteries, plastic containers and wooden crates that contained cyanide.

Cyanide Management
Because of the potential risk of contamination with cyanides, empty packaging should be disposed of so as not to be recovered by the local population.

Packages must be rinsed or sterilized by a chlorine dioxide solution. They will be flattened and incinerated on the landfill site located within the TSF.
Vehicle batteries can be sent to a recycling process.

Batteries and slag of gold calciner will be mixed with cement and packaged in sealed drums.</td><td>Included in the operational costs of the respective departments</td></tr>
<tr><td colspan="2">Laboratory waste
Although the quantities produced can be considered as very low, all acidic solutions, aqueous solutions (which contain cyanides) and solvent will be recovered in separate containers for further processing. The aqueous solutions containing cyanides will be maintained at a pH with high lime to prevent volatilization.

Generally, acids and aqueous solutions may beings sent to the tailings pond where they will naturally oxidized. Solvents, mainly the DIBK (Di Iso-Butyl Ketone) may be either treated as above or may be burned or be destroyed by the effect of ultraviolet after sun exposure in trays.

The packages with chemicals are rinsed and taken to the local landfill.</td><td>Included in the operational costs of the respective departments</td></tr>
</table>

5.11 MATRIX OF MITIGATION MEASURES

Mitigation measures for landscape impact				
Identification of impact			**Mitigation measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Earthworks, mining and tailings storage	Landscape degradation	Permanent damage to the aesthetics of the site making it unattractive and difficult to live.	Implementation of a rehabilitation and revegetation program of stripped areas from earthworks.	Part of the rehabilitation (Chapter 7.0) and environmental management (operational costs) budgets
			Reduce the number of trees cut down to the minimum required by raising public awareness and mine workers.	Procedure for Environmental Management (Chapter 6.0)

Mitigation measures for impacts on the atmospheric environment during construction period				
Identification of impact			**Mitigation measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Movement of vehicles on roads	Dust formation	Timely and localized increase in dust levels can hinder users and increase the risk of accidents	A tanker evenly disperses water on the roads to keep them sufficiently wet limiting the conditions under which the dust is generated	Part of the environmental management budget
			On the project site, the speed of vehicles will be regulated by signs posted in various parts of the site.	Part of the environmental management budget
			Strict guidelines will be distributed to subcontractors and vehicle drivers to ensure they do not exceed the speed limit. These instructions are inserted into specific clauses in contracts to subcontractors.	Environmental management procedure
Earth works	Dust formation	Localized increase in fine particles that land on the vegetation	Bare surfaces will be kept to a minimum, especially in work areas. Bare areas will progressively grassed.	Part of the environmental management budget

Mitigation measures for impact on atmospheric environment during operation				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Ore crushing	Dust formation from fixed sources	Timely increase in dust levels can affect the health of workers crushing station.	Masks for protection against dust will be distributed to the workers.	Health and hygiene management procedure. The cost of protective masks is included in the operating budget.
Combustion ovens	Dust formation from fixed sources	Small-time increase of PM10 dust levels. The particles disperse very rapidly in the atmosphere	Installation of a chimney at the highest point of the plant	Part of operations budget
Movement of vehicles on dirt tracks	Dust formation from diffuse sources	Timely and localized increase in dust levels may hinder the users of different tracks and increase the risk of accidents	Limiting traffic speeds and regular watering of tracks by water tankers. The frequency of watering will depend on weather conditions and tracks attendance.	Part of the environmental management budget.
Working with explosives	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries.	The use of an explosive system that could reduce the emission of dust. The explosion areas will be minimized and the wind direction will be	Part of the operational and environmental management budgets
Wind on surface	Dust formation from diffuse sources	Potential increase in dust levels in the atmosphere near the quarries	Bare surfaces are watered regularly during dry periods to prevent dust.	Part of the environmental management budget.
Diesel engines	Production of greenhouse gases	Increasing carbon levels in the atmosphere and other gases (SO_2 et NO_2)	Selection of diesel vehicles using quality products; development of a preventive maintenance program; immediate repair of vehicles and regular review of vehicle breakdowns.	Operational budget of the project
Laboratory analyses	Gas emissions	Increase the amount of gas that would threaten the health of laboratory operators	Installation of laboratory extractors equipped with fume recovery filters.	Operational budget of the project

Mitigation measures for cumulative impacts on atmospheric environment				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Adding a third crusher	Increasing the amount of dust on the plant site	Increase in dust levels can harm employees	Using protective masks against the dust	Part of the environmental management budget.
Construction of the WWTP	Increasing the amount of dust on the plant site	Increase in dust levels can harm employees	Surfaces regularly watered to reduce air emissions	Part of the operational and the environment management budget
Construction of the airstrip	Increasing the amount of dust on the plant site	Timely and localized increase in dust levels can harm employees	Surfaces regularly watered to reduce air emissions	Part of the operational and the environment management budget
Mitigation measures for interactive impact of water, soil and land				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Operation of the camp and administration	Increased organic matter in surface water, soil infertility, decreased agricultural yields	Domestic wastewater may cause an increase in organic matter in surface water, leading to soil infertility, low permeability of irrigated soils and declining agricultural output	These effluents will be drained through a sewer system to the treatment plant and undergo several processing steps to meet the discharge standards. Surfaces will be grassed where possible to reduce erosion.	Good environmental and operational management procedure.

Mitigation measures for noise and vibration impact				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Crushers, processing plant and mining equipment	Continuous noise	Levels above 85 dBA noise can affect hearing ability of workers and the surrounding population	Every worker will receive hearing protection.	About $ 500 for a dozen helmets
			Making noise measurements for identification of potential impact. Build sound barriers if necessary to protect the surrounding population.	Part of the environmental management budget.
Work with explosives in the three quarries	Noise and vibrations	Effects on the inhabitants	Using modern techniques with explosives by a competent contractor with experience in the subregion.	Good operational management procedure
			To minimize the surprise of detonations on people, the company will ensure that the explosion hours will be communicated in advance to the inhabitants of Sissingue, as well as local residents.	Good operational management procedure
			The vibrations generated by blasting with explosives could create cracks in the buildings of the villages mentioned above. Therefore, the buildings structural conditions will be regularly monitored and photos will be taken as supporting evidence.	A camera, a database and a good procedure for environmental management
			During each explosion, noise and vibration levels will be measured at about 500 m from the quarry.	US $ 3,000 for the purchase of the unit and good procedure for environmental management
Takeoff and landing of aircraft on the runway	Increased level of noise	Aircraft could increase the noise level at the mine site during takeoff and landing	Using protective masks against noise	Part of the environmental management budget
			Establishment of a complaints management plan related to noise on the runway	Part of the environmental management and operation budget

Mitigation measures for impacts on the aquatic environment during the construction period				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Site preparation and surface blasting	Poor quality of surface water	Increase in silting of river	Sedimentation basins will be built at the lowest point of the site of the processing plant and ore storage. The edges of these ponds will be planted with grass or riprapped.	US $ 4000 for the areas located downstream of the treatment plant. The edges of these ponds will be planted with grass or
Machine use in site preparation	Poor quality of surface water	Oil spills affecting river quality	As a safeguard, the company will introduce requirements to protect and respect the environment in the contracts of subcontractors. It will be stipulated for example to use well-maintained vehicles, storing hydrocarbons on appropriate retention areas or to clean up a site Accidental pollution caused due to a breach of covenants.	Good environmental and operational management procedure.

Mitigation measures for impacts on the aquatic environment during the construction period				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Site preparation	Poor quality of surface water	Increased organic matter and pathogens (coliform)	Domestic effluents from toilets will be drained into septic tanks.	Around US$ 1 000

Mitigation measures for impacts on the aquatic environment during operations				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Clearing the ground for works	Disruption of hydrological regime	Changing the runoff coefficient due to changes in topography and surface conditions that can foster a quicker flow	The design and construction of the project works include the installation of a network of diversion ditches, drainage channels, sedimentation basins, culverts, etc. to minimize the negative effects of increased runoff coefficient.	Included in the cost of design and project investment capital
Pumping water to fill the water balance deficit	Disruption of hydrological regime	Changing the flow rate and the possibility of the Bagoé drying up of for extended periods, which may affect the aquatic ecosystem	Pumping water from the Bagoé will be restricted to rainy periods. When pumping water from the side of the left bank of the Bagoé owned by the Republic of Côte d'Ivoire, the company will send a request to the administrative authorities (Department of Hydraulics and Water Resources Management).	Good environmental and operational management procedures
Water discharge from the mine due to heavy rain	Disruption of hydrological regime	Slight modification of stream flow but should not affect the functions of the aquatic ecosystem, especially downstream of the project area	Conserve this water and reuse it to water the access road and the tracks inside the mine.	Operational budget and part of the environmental management budget
Accidental discharge of effluent following the drilling of a pipe, hose rupture, etc.	Poor quality of surface water	Effluents containing cyanide that reach waterways can have a negative effect on the aquatic ecosystem downstream of the project area	The majority of solutions containing cyanides are in the processing plant. All tanks, pipes or pumps in contact with cyanides include a retention area can recover accidental leaks.	Included in the design cost and the project's investment capital
			Regular inspections of pumps, pipes, tailings dam and the seepage collection pond will be conducted by the department in charge of the process	Good operational management procedure
			Accidental spills with cyanides, calcium hypochlorite will be available to detoxify the area that was accidentally contaminated. Calcium hypochlorite can be dispersed manually on cyanide solutions which have escaped from the circuit. Cyanides are oxidized to form a non-toxic cyanate compound and finally carbonates and ammonia.	US $ 1000 for a decontamination kit and good procedure for environmental management

Mitigation measures for impacts on the aquatic environment during operation				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Accidental discharge of effluent following the drilling of a	Poor quality of surface water	Effluents containing cyanide that reach waterways can have a negative effect on the aquatic ecosystem downstream of the project area	The quality of surface water downstream of the plant and the TSF will be monitored regularly by the environment department. Monitoring will include an analysis of pH, conductivity, cyanide and heavy metals.	Part of the environmental management budget (Chapter 6.0)
Water discharge into the environment in	Poor quality of surface water	Potential deterioration of the quality of streams that could affect the functions of the aquatic ecosystem	Water discharges from the mine will be done in a controlled manner. Their quality will be continuously monitored in case the drainage water should be rejected	Part of the environmental management budget
TSF and other project areas	Poor quality of surface water	Possibility of siltation affecting the functions of the aquatic ecosystem	Runoff draining of TSF and processing plant where the ore is stored, will be directed into the environment via sedimentation basins.	Included in the design cost and the project's investment capital
			Early rehabilitation and revegetation sites and exposed areas will be systematically considered.	Good operational management procedure (operational costs)
			The quality of surface water at the basins will be monitored regularly by the environment department. Monitoring will include an analysis of pH and TSS.	Part of the environmental management budget
Oxidation of sulfur rock and acid drainage	Poor quality of surface water	Drainages acids formed during oxidation of rocks containing sulfides can generate toxic effluents in the aquatic environment	During operation, the acid potential tests will be performed regularly on samples of tailings and ore during their extraction. If a problem occurred it is still possible to take appropriate measures such as encapsulation of reactive material.	Part of the environmental management budget
Domestic effluents and contents of septic tanks	Poor quality of surface water	Increased organic matter and pathogens (coliforms) can contaminate surface water	Domestic effluents from camp and other sites' toilets will be drained in septic tanks.	Around US$ 15 000
			When septic tanks are filled mining company Perseus Mining will contact a company responsible for the management of waste water disposal according to Ivorian procedure.	Part of the environmental management budget

Mitigation measures for impacts on the aquatic environment during operation				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Hydrocarbon leakage into the environment	Poor quality of surface water	The presence of large quantities of hydrocarbons on the site, the use of vehicles and heavy equipment and their maintenance requires special management to prevent their loss to the environment and an introduction into rivers	Each tank containing hydrocarbons will be built on a concrete containment area that will hold the volume of at least one tank in case of breakage.	Included in the cost of design and project investment capital. This measure will also be imposed on
			The drums containing oils will be stored on an impervious area.	Included in the cost of design and project investment capital.
			The workshops will be constructed on an impervious surface for directing all losses to a recovery pit leading to a hydrocarbon separator. The fat accumulated in these systems will be eliminated by the supplier of petroleum products in an appropriate site.	Included in the cost of design and project investment capital.
			As a safeguard, the company introduces requirements for the protection and respect of the environment in the contracts of subcontractors.	Good environmental and operational management process.
Transport (Chemical spills)	Poor quality of surface water	The presence of significant amounts of chemicals in rivers.	A good convenient transportation and handling of these chemicals should be taught to officers committed to the task. Effective and immediate cleaning of spills. Transporting chemicals only during the day.	Good environmental and operational management process.
			As a safeguard, the company introduces requirements for the protection and respect of the environment in the contracts of subcontractors.	Good environmental and operational management process.
Pumping for potable water	Poor quality and decrease in the amount of groundwater	Pumping rates will be low and consistent with the nature of the aquifers in the project area. No impact should be observed.	Install an electric pump whose pumping rate will not be higher than the drilling. That is to say, an adequate volume of good quality water according to the operating license.	Investment budget

Mitigation measures for impacts on the aquatic environment during operation				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Seepage from the tailings	Poor quality and decrease in the amount of groundwater	Water seepage circulating in the groundwater of the regolith and could result in long term contamination of deep groundwater (fracture type) and surface water downstream	A recovery system filtering water will be installed at the base of the dam. It will consist of a trench about three meters deep and 5 meters wide which will aim to collect seepage at the interface. Such seepage of water will be collected in a small pond built downstream of the dam, and then pumped to the tailings or to the ore processing plant to be used in the process.	Included in the cost of design and the investment capital of the tailings facility.
			An observation site with two wells will be built downstream of the TSF. A shallow well to detect possible pollution from filtering water and deeper wells to monitor potential changes in groundwater quality in depth. Samples will be taken regularly for a determination of parameters such as pH, conductivity, cyanides and heavy metals (sodium, calcium, potassium, magnesium, chloride).	Part of the environmental management budget
Seepage of chemical products	Poor quality and decrease in the amount of groundwater	Chemicals penetrated the ground water and long term contamination of ground water (fracture type)	A good practice of transport and handling of these chemicals should be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effective and immediate cleaning should be carried out. Transporting chemicals the day only.	Good environmental and operational management procedure.

Mitigation measures for impacts on the ecological environment during construction and operation period				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/Source of impact	**Impact identified**	**Analysis**		
Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast).	The development of the project should not cause the destruction of forests or habitat with significant ecological value.	Deforestation sites will be selective and gradual. Before any surface preparation work, the topsoil will be identified and recovered to be used for rehabilitation purposes.	Good environmental and operational management procedure.
		The development of the project should not cause the destruction of forests or habitat with significant ecological value.	Sites rehabilitation activities will be initiated from the beginning of operations and will include the replacement of rare species.	The preliminary program and the costs of the mine rehabilitation are presented in Chapter 7.0.
Influx of population in the project area	Indirect effects on the ecological environment	Increase in hunting and the chopping down of trees for firewood	The inclusion in contracts of employees and subcontractors of a clause prohibiting hunting on the entire license area. On site monitoring of hunting will be performed by employees who travel frequently on different roads in the area.	Good environmental and operational management procedure.
			The display in various locations in the future posters wealth of animal and plant species considered "rare" or vulnerable. The environmental training course, which will be provided to all employees, include a module "Conservation of fauna and flora"	Good environmental and operational management procedure
Takeoff and landing	Risk of accidents by hitting birds or mammals	The risk of accidents can occur on runways by hitting birds or mammals	Fully fenced mining area	Part of the environmental
			Setting up a barrier plan	Part of the operational and the environment management budget.

Mitigation measures for the impact of soil environment during construction and operation periods				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of impact	**Impact**	**Analysis**		
The various activities of site preparation and the exposure of large areas of land	Soil erosion	Site preparation activities can lead to loss of land, while leaching of fine particles may cause pollution of surface waters	Limit deforestation and surface blasting to the minimum required.	Good environmental and operational management
			Apply appropriate management of natural flows and isolate the bare areas such as quarry, TSF or ore storage area by the construction of runoff diversion ditches. In addition, runoff water will be discharged into the environment.	Included in the design cost and the investment capital of the project works.
			Regular monitoring of the effectiveness of measures and techniques adopted by visual inspection and determination of suspended solids in surface water during the wet season.	Part of the environmental management budget.

Mitigation measures for impact of soil environment during construction and operating period				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of impact	**Impact identified**	**Analysis**		
Poor handling or accidental release of hazardous chemicals during transport	Soil erosion	Poor handling or spills of hazardous chemicals and seepage of heavy metals from works such as the TSF or tailings poured could contaminate the soil.	Good practice of handling these dangerous chemicals must be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effectively and immediately cleaned. Cyanide management should meet international standards.	Environmental management process and part of the environmental management budget.
Development of project works and road construction	Destruction of farms	The development of project works will cause a loss of farming	Farmers with fields and crops and the landowners affected by the project activities will be financially compensated according to regulations. An accurate assessment of fields and crops will be carried out during the construction period.	Estimated Project Budget
			Prior to construction, the area and the influence of the works must be accurately known to avoid massively destroy crops.	Good environmental management and operational procedure

Measures for positive impact on socio-economic environment				
Identification of impact			**Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Creation of new jobs	Training and employment	The project will create about 300 direct jobs and many temporary jobs. The training will be at the heart of the project development strategy.	Young people from the project area and the region will be used in priority after a selection based on the general suitability of the person.	Good environmental and operational management procedure.
Payment of taxes	Royalties	Improving the living conditions of the population through the payment of taxes to the State of Côte d'Ivoire to strengthen the infrastructure of the region.	This impact will be strengthened through a process of consultation between all the political, social and economic players. The company will comply with the laws in force.	TBD.
Mitigation measures for negative impacts on the socio-economic environment				
Identification of impact			**Mitigation measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Development of various project works	Displacement of the population in nearby hamlets	Some isolated hamlets on the location of important works would be affected. Any population displacement is considered a very complex process because it requires not only ensure a new home (if necessary) but also continuity of their livelihoods	A displacement plan (physical and / or economic) will be prepared by a specialist. A participatory process will be completed and the implemented by Environment Staff Perseus Mining Ivory Coast. An arbitration committee will be established to resolve conflicts that might arise.	An amount of US $ 60,000 has been provided for this purpose.
			Displaced persons who have received monetary compensation for their loss of income will be encouraged to participate in training programs for the development of alternative projects and training investment.	An amount of US $ 30,000 has been provided for this purpose

Mitigation measures for negative impacts on the socio-economic environment				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Development of the gold mine	Massive influx of population	The opening of the mine in the area will attract a number of people looking for work. Any increase in population in villages already inadequate basic infrastructure can enhance the magnitude of the problem. On the other hand, an additional influx of “foreigners" can increase tension between indigenous peoples, immigrants and non-indigenous.	As a social partner, the company is committed to maintaining dialogue and contact with government and traditional authorities, in order to monitor, prevent and possibly propose solutions with a view to joint development with communities. For example, it is important to ensure that the number of jobs that could be generated is shared with local officials and populations of villages in the project area and the sub-prefecture of Kanakono. This should help avoid overly ambitious expectations among the population and may affect immigration in the villages in the project area and at the sub-prefecture of Kanakono.	Good environmental and operational management procedure.
			One of the most sensitive infrastructures is drinking water. Therefore, Occidental Gold is committed to building an enhanced village water system (HVA) to increase the current capacity to supply Sissingue.	Study cost of US$ 65 000
Development of the gold mine	Weakening of social power	Reduced power of the village chief and his chiefs could weaken social cohesion necessary for a harmonious and peaceful development of the project	For the consultative process to be effective, the rule of Sissingue village leader will be admitted. Also local recognition of the land chief is needed to strengthen social cohesion. Any decision must be collegial.	Good environmental and operational management procedure.

Mitigation measures for negative impacts on the socio-economic environment				
Identification of impact			**Mitigation Measures**	**Associated Costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Construction of the ore processing plant	Disappearance of sacred sites or burial sites	The sacred Navigo site on the area required for the development of the gold project could disappear. The population may fear the desecration and the loss of sacred sites	Concerned villagers may participate in the implementation and monitoring of site protection measures and ensure, wherever possible, access to the site at all times.	Good environmental and operational management
			Moving the sacred Navigo site on the area required for the development of the gold project	An amount of US $ 3,000 was provisioned for this purpose.
Development of the gold mine	Problems associated with development	The development can have an indirect negative effect through increase of illegal activities	Continuous dialogue with the social partners and information from mine employees and local populations.	Good environmental and operational management procedure.

Mitigation measures for negative impact on remains				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Digging of quarries and pits	Destruction of important remains	No particular archaeological sites were discovered in the project development area. Some remains such as ceramics fragments were found northeast of the project development area.	A specialist of the Institute of Arts and Archaeology of Abidjan will be contacted for extracting remains .question.	An amount of US $ 7,000 was provisioned for this purpose.

Mitigation measures for negative impacts on community health				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Development of the gold mine	Problem of development of diseases	Mining operations can inevitably cause negative indirect effects linked to all sorts of diseases	Perseus Mining will carry out educational and awareness campaigns for employees and community.	Good operational management and Social Development procedure.
			Health monitoring program and medical clinic for employees on site.	Operating budget of monitoring health
			Food hygiene inspections (eg practices and food handling equipment)	
Mitigation measures for impact of non-mining waste				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Operation and servicing of the site	Non-mining waste	The various types of waste (solid household, industrial, special industrial and laboratory) generated can pollute the environment, including the air surface- and groundwater and soil.	***Solid household waste*** This type of waste will be produced by the administrative and technical offices, canteen and households. This waste will be collected on site and transported to a landfill that will likely be built in the TSF or low permeability site. Within the structure, trenches are opened, filled and covered with inert material, in this case of non-mineralized rock. Stored materials are compacted or burned to prevent dispersal by wind.	Included in the operational costs of the respective departments.

<table>
<tr><th colspan="5">Mitigation measures for impact of non-mining waste</th></tr>
<tr><th colspan="3">Identification of impact</th><th rowspan="2">Mitigation Measures</th><th rowspan="2">Associated costs</th></tr>
<tr><th>Activity/ Source of</th><th>Impact identified</th><th>Analysis</th></tr>
<tr><td rowspan="2">Operation and servicing of the site</td><td rowspan="2">Non-mining waste</td><td rowspan="2">The various types of waste (solid household, industrial, special industrial and laboratory) generated can pollute the environment, including the air, surface- and groundwater and soil.</td><td>Ordinary industrial waste

This class of waste mainly includes tires, metal parts, pipes, screens and other used equipment and materials from the processing unit and packaging waste to non-toxic products (plastics, paper, cardboard).

If recycling processes cannot be found locally and at an economically acceptable time, this category of waste will also be sent to the local landfill, in the same way as solid household waste. Often used tires and metal parts can be resold.</td><td>Included in the operational costs of the respective departments</td></tr>
<tr><td>Used oil and oil filters as hazardous industrial waste (HIW)

Drain oils will be produced at the processing unit and in the various workshops and systematically collected and disposed of by the contractor and supplier of petroleum products to a recycling process.

Oil filters are drained and transported to landfill.</td><td>Included in the operational costs of the respective departments.</td></tr>
</table>

Mitigation measures for impact of non-mining waste				
Identification of impact			**Mitigation Measures**	**Associated costs**
Activity/ Source of	**Impact identified**	**Analysis**		
Operation and servicing of the site	Non-mining waste	The various types of waste (solid household, industrial, special industrial and laboratory) generated can pollute the environment, including the air by odors, surface and groundwater and soil.	***Other HIW*** Special or hazardous industrial waste include batteries, plastic containers and wooden crates that contained cyanide. Cyanide Management Because of the potential risk of contamination with cyanides, empty packaging should be disposed of so as not to be recovered by the local population. Packages must be rinsed or sterilized by a chlorine dioxide solution. They will be flattened and incinerated on the landfill site located within the TSF. Vehicle batteries can be sent to a recycling process. Batteries and slag of gold calciner will be mixed with cement and	Included in the operational costs of the respective departments
			Laboratory waste Although the quantities produced can be considered as very low, all acidic solutions, aqueous solutions (which contain cyanides) and solvent will be recovered in separate containers for further processing. The aqueous solutions containing cyanides will be maintained at a pH with high lime to prevent volatilization. Generally, acids and aqueous solutions may beings sent to the tailings pond where they will naturally oxidized. Solvents, mainly the DIBK (Di Iso-Butyl Ketone) may be either treated as above or may be burned or be destroyed by the effect of ultraviolet after sun exposure in trays. The packages with chemicals are rinsed and taken to the local landfill.	Included in the operational costs of the respective departments

6.0 PRELIMINARY PLAN OF ENVIRONMENTAL MANAGEMENT

6.1 INTRODUCTION

6.1.1 Aims and objectives of the Preliminary Plan of Environmental Management

This chapter of the environmental impact study presents the first version of the Environmental Management Plan (EMP). The environmental management and monitoring plan for a mining project is a practical document that must be updated continuously from the start of the construction period and during operations, and the end of term for the rehabilitation of the site. In general, this support plan includes all activities and measures to be undertaken by the mining company to manage and control the state of the environment of the site, coordinate the implementation of project mitigation measures and follow efficiency, maintain ongoing communication with all parties involved (authorities, population, NGOs, etc.), prevent and manage potential accidents and rehabilitate the site.

6.1.2 General Structure of the EMP

The general structure of the EMP:

1. Introduction
2. Perseus Mining Environmental Policy in Ivory Coast
3. Structure and organization of Sustainable Development Staff (DD)
4. Financial resources
5. Project Description
6. Summary of impacts and compensatory measures
7. Control programs and environmental monitoring
8. Communication and community development programs
9. Waste management
10. Plan for rehabilitation and closure
11. Aspects of health and safety
12. Emergency response plan
13. Audit Operations
14. Matrix Environmental Monitoring Plan

6.2 PERSEUS MINING ENVIRONMENTAL POLICY IN IVORY COAST

6.2.1 Environmental, Health and Safety Policy

Perseus Mining Ivory Coast acknowledges that its activities continuously interact with the environment. Therefore, it is committed to ensuring that all operations are conducted in a responsible manner in order to protect and promote the environment and the health and safety of its employees, contractors and social partners.

Its objective is to excel in the field of sustainable development, including environmental, health and safety (EHS) and communication. Each employee must actively support its policy and its implementation in accordance with the following commitments:

Environmental policy

- Respect the standards and laws of the country in which the company operates and excel beyond the expectations surrounding its activities;
- Identify the environmental impacts of activities and implement appropriate recommendations to minimize the associated risks;
- Have sufficient resources to achieve the environmental goals, including the effective and sustainable mine closure;
- Develop, implement and continuously improve the environmental management system to ensure that environmental processes are integrated in all activities and even in the organization of the company;
- Ensure employees and contractors are trained in the individual responsibility of environmental management;
- Contribute to the protection of biodiversity in all areas of operation;
- Communicate honestly and openly consult all stakeholders to ensure transparency regarding environmental performance;
- Maintain an effective emergency prevention system to meet the health and safety related effects;
- Put in place effective measures to prevent pollution of groundwater, surface water, soil and air and minimize impacts on wildlife and vegetation;
- Ensure that waste management is carried out appropriate and practical, and waste disposal strategies including reduction, reuse and recycling are effective;
- Present reduction initiatives for water and power consumption to conserve natural resources and minimize emissions of greenhouse gases;
- Implement effective systems to reduce or eliminate environmental hazards related to transportation, storage, handling and disposal of hazardous materials;
- Check environmental performance audits, workplace inspections and environmental analysis to identify potential impacts and propose corrective measures.

Health and safety policy:

- Provide a work place that effectively contributes to the management of health and safety;
- Complete a minimum of health and safety standards including other regulations;
- Continually seek to improve occupational health and safety performance by using available technology, knowledge and practice management;
- Identify the health and safety risks and implement the recommendations to eliminate the injury / illness at work through an organization;
- Develop, implement and continuously improve the health and safety management systems and ensure that the practices are integrated in all units of the company;
- Educate and train all employees and contractors by providing information for them to be responsible in their area;

- Have sufficient resources to meet the health and safety objectives of the mine;
- Review, monitor and evaluate the health and safety performance during the operational period to make improvements;
- Communicate and consult all stakeholders on security issues;
- Maintain an effective emergency prevention system to meet the health and safety related effects;
- Implement effective systems to reduce or eliminate the risk of health and safety related to transportation, storage, handling and disposal of hazardous materials.

Community Relations Policy

- Ensure employees and contractors recognise and respect cultural heritage and cultural diversity;
- Maintain ongoing dialogue with local communities to ensure early identification and understanding of potential issues;
- Establish long-term relationships and trust with the community-based communication through sincere and open consultation;
- Create a fair and equitable approach to solving the problems of the community in a consistent manner;
- Give priority for employment and training to communities in the project area;
- Support the development and implementation of sustainable social and economic initiatives through cooperation and community participation;
- Promote local activities that will have benefits for the local community;
- Observe a standard of respect regarding all social and other requests that our company is accountable for vis-à-vis the legislation;
- Develop and implement effective management systems to identify, assess, monitor and review the social impacts of the operations.

6.2.2 Key elements of the environmental management system

The company recognizes that appropriate management of the environment is essential to carry out the operations of the project. Perseus Mining Ivory Coast will develop an environmental management system whose key elements will revolve around the following points:

- the concept of liability and accountability of all employees in order to minimize environmental risks and comply with current regulations as well as the environmental policy of the company;
- the establishment of an environmental monitoring and control program to identify risks at an early stage;

- Training and orientation of employees in order to provide strategies that will allow them to perform their duties in accordance with good environmental practices;
- consideration of environmental criteria when developing structures, including purchasing materials and equipment;
- risk management through the preparation of emergency procedures in case of environmental problems;
- the establishment of a reporting system and communication of environmental incidents to the appropriate authorities;
- the establishment of a process of effective dialogue between the company and all political, social and economic stakeholders;
- the environmental audit and periodic internal or external review in order to establish the degree of compliance of environmental management at different levels of the hierarchy in the company;
- the establishment of communication procedures and dialogue with the authorities to constantly monitor regulatory issues.

There are also standards of environmental and community performance for the following:

- Standard 20 - Water management
- Standard 21 - Atmospheric emissions (including dust and noise)
- Standard 22 - Biodiversity
- Standard 23 - Greenhouse and Energy
- Standard 24 – Socio-Economics
- Standard 25 - Oil Management
- Standard 26 - Exploration Drilling
- Standard 27 - Rehabilitation
- Standard 28 - Engagement of Stakeholders
- Standard 29 - Waste Management

6.3 STRUCTURE AND ORGANISATION OF SUSTAINABLE DEVELOPMENT

The Sissingue gold project will have a structure that will include environment, community relations, health and safety officials. These officials will be in place and operational at the start of construction of the mine.

Staff recruitment will be gradual, according to the progress of mining activities.

Leaders of various mining departments will be responsible for the environment within their Department.

In order to carry out their duties and to have an authority recognized by the other leaders, both officers of the department (responsible for environment, health and safety and communication manager and social affairs) report directly to the Director General of Mining.

The mission of the Sustainable Development of operations will be accomplished through control, monitoring, training, information and ongoing dialogue.

6.4 FINANCIAL RESOURCES

Perseus Mining Ivory Coast will establish appropriate and adequate financial resources to achieve the goals and programs for the management and control of the environment.

A quantification of these resources was made and comes in**Table 6.1** below.

Table 6.1 Quantified assessment of financial resources for achieving the objectives and programs

Investment	
Category	**Cost (US$)**
Purchases for laboratory equipment measuring environmental parameters (pH, conductivity, TSS, cyanide tests, balance, oven, noise analyzer and vibration, monitor dust, glass, weather station, consumables, sail photo, GPS)	50 000
Construction of the laboratory	10 000
Construction of the nursery (nets, poles, tank, tools)	20 000
Office materials (computers, printers, etc.)	15 000
Total	**95 000**
Operation	
Category	**Annual costs (US$)**
On site Environmental Analyses	35 000
Environmental analyzes made by an external control laboratory	40 000
Nursery management (purchase of new seedlings etc)	25 000
Salaries for technicians	45 000
Training costs	30 000
Miscellaneous costs (recruitment for temporary, unexpected, etc.)	35 000
External and internal audits	40 000
Total	**250 000**

6.5 DESCRIPTION OF THE PROJECT

The second version of the Environmental Management Plan will include a description of the Sissingue gold project which will reflect any changes made to the project's feasibility study and this environmental impact study. This description will focus on the critical points of various mining and processing operations. The structure of this chapter and the type of information presented will be similar to the initial description of the Environmental and Social Impact Assessment report.

6.6 SUMMARY OF IMPACTS AND MITIGATION MEASURES

This chapter summarizes the various impacts and mitigation measures for the project as presented in Chapter 5.0 of this document.

6.7 CONTROL PROGRAMS AND ENVIRONMENTAL MANAGEMENT

6.7.1 Overview

Continuous monitoring of indicators of environmental quality is an essential part of the Sissingue gold project. The monitoring program is considered a powerful management tool because it will allow the quick detection of any abnormal operation of a particular activity and also to confirm the environmental balance of the project.

6.7.2 Meteorological Data

Currently, there are very few meteorological data on the project area. The nearest stations, which only measure rainfall, are those of Kouto and Papara. The nearest synoptic station is Korhogo, some 200 km southeast of Sissingue.

Perseus Mining Ivory Coast will install a weather station to measure the minimum rainfall, temperatures and evaporation daily.

These data are significant because they allow the ability to follow the parameters of the water balance of the process and also to make predictions on hydrological phenomena on the site.

6.7.3 Hydrological Data

The hydrological regime of rivers in the project area is directly related to rainfall. No measuring station has been established. As the waters of the Bagoé will be used for the needs of the ore treatment process, it is important to install a measuring station near the sampling site.

On the recommendation of the interdepartmental committee of validation of the environmental and social impact assessment report, the measurement stations will be installed on the Bagoé River and Perseus Mining Ivory Coast will maintain records of these measures in agreement with the National Office of Drinking Water and the Water Resources Branch. The sites will be chosen based on the needs of stakeholders.

6.7.4 Measurements of groundwater levels

The environmental monitoring program will provide for the monitoring of seasonal fluctuations and levels of aquifers through the installation of monitoring wells and points of quality control of groundwater.

This monitoring will establish the incidence of certain project activities, including the extraction of ore. To this end, regular measurements will be taken at the existing Sissingue borehole.

6.7.5 Measurements of surface water

A sampling of the physico-chemical quality of surface water program will be set up in order to monitor and verify the proper functionality of the project. The sampling points will be made throughout the Bagoé river which forms the natural border between the Ivory Cost and Mali. They will be located upstream and downstream of the project area.

This water quality monitoring program of the Bagoé River will be established in agreement with the National Office of Drinking Water and the Water Resources Branch.

The selected parameters and the sampling frequency will depend on the site to control and follow. Some parameters such as pH and conductivity are measured daily at certain sampling points. Suspended solids, cyanide, arsenic and hydrocarbons will be measured with a frequency appropriate to the amount of rainfall.

A detailed sampling program will be prepared for the second version of the ESMP, just before the construction period. It will be updated regularly.

6.7.6 Measures of the quality of the ground water

A similar water sampling program will be set up. It will monitor changes in water quality in the vicinity of the quarry and TSF. Drinking water for human consumption will also be monitored, particularly in the village of Sissingue. Sampling frequencies will be defined on the basis of one year of observations where measurements will be made quarterly. The parameters such as pH and conductivity will be measured more frequently downstream of the TSF.

A detailed sampling program will be prepared for the second version of the ESMP, just before the construction period. It will be updated regularly.

6.7.7 Air quality control

A dust concentrations measuring program will be implemented. The measurement equipment will be located at the quarry, the processing plant and the village of Sissingue.

6.7.8 Noise and vibrations

Noise levels will be measured from the start of operations in and near the facilities of the project, at sensitive sites such as the village of Sissingue. During each explosion, noise and vibration levels will be measured at about 500 m from the quarry. A noise management plan will be implemented from the start of mine construction.

6.7.9 Monitoring impacts on the ecological environment

The potential impacts on the ecological environment could be measured by conducting monitoring campaigns and general observations of the fauna and flora. These campaigns will be conducted by the responsible environmental authorities. Collaboration will be explored with students as part of their research.

6.7.10 Erosion Control

The erosion monitoring and control measures in place against this phenomenon include:

- visual observations as routine preventive measures that will allow early detection of erosion and rapid introduction of corrective measures;

- regular inspections of runoff control structures;
- sampling and analysis of runoff at sites identified as sensitive.

6.7.11 Environmental Norms

Parameters	WB/IFC Standards	WHO drinking water
pH	6.0-9.0	-
True colours	-	15 [a]
Turbidity	-	5 NTU [a]
Dissolved solids	-	1000 [a]
Suspended solids	50	-
Sodium (Na)	-	200 [a]
Chlorures (Cl^-)	-	250 [a]
Nitrate (NO_3-N)	-	50 (as NO3)
Nitrite (NO_2-N)	-	3 (as NO2)
Sulfates (SO_4)	-	250 [a]
Fluorine	-	1.5
Free Cyanide	0.1	0.07
Total Cyanine	1.0	-
WAD Cyanide	0.5	-
DBO5	50	-
DCO	250	-
Oils and fats	10	-
Fe (Total)	3.5	0.3 [a]
Mn (Total)	-	0.5 [P]
Cu (Total)	0.5	1 [a], 2 [P]
Zn (Total)	2.0	3 [a]
Pb (Total)	0.1	0.01
Hg (Total)	0.01	0.001
Cr (Total)	0.1 (Cr^{+6})	0.05 [P]
Ni (Total)	0.5	0.02 [P]
As (Total)	0.1	0.01 [P]
Cd (Total)	0.1	0.003
Al (Total)	-	0.2 [a]
Ag (Total)	0.5	-
Sb (Total)	-	0.005
Se (Total)	0.1	0.01
* Standards for the quality of drinking water, 2nd ed. 1996; Concentrations in ppm except pH, conductivity and color (flat. Cobalt units and mS / m) a: Value can lead to consumer complaints; P: Interim Standard		

Norms and standards for ambient particles						
Norms	Long-term Annual (µg/m³)		Short-term (24 hours) (µg/m³)		Occupational exposure over a period of 8 hours (mg/ m³)	
	PM10	**TSP**	**PM10**	**TSP**	**PM10**	**TSP**
OMS(1983) / BM(1995)	-	100	150a	500	-	-
SFI (2003)	40	-	50	-	3	10
OMS Europe	50	-	125	-	-	-
EPA primary and secondary	50b	-	150c	-	-	-

a: The World Bank will consider an area moderately degraded if the 98th percentile values Averages 24/24 during a year period exceeds 150 mcg / m3 of PM10.

b: Arithmetic Average

c: threshold values for the combined exposure of oxygen and sulfide PM10 = Respirable Particulate therefore less than 10 microns in diameter

TSP = Total Suspended Particulate

EPA: Environmental Protection Agency of the United Nations

WB/IFC Standard for noise and vibrations					
Ambient noise			**Vibrations and sounds from explosions**		
Zone	**Day (07:00 - 22:00)**	**Night (22:00 - 07:00)**		**Maximum**	**95%- of the time**
Residential, Institutions, Natural Areas	55	45	Ground vibration	Peak Particle Velocity PVP < 10 mm/s	PVP < 5 mm/s
Industrial, commercial	70	70	Noise	Peak Particle Velocity < 120 dB Linear	< 115 dB Linear

6.8 COMMUNICATION AND COMMUNITY DEVELOPMENT PROGRAMS

6.8.1 Overview

Perseus Mining is committed to maintaining excellent relations with local communities. A team will be directly responsible for managing all the relational aspects with the people and the authorities. This includes the resolution of the displacement of hamlets, compensation for fields, public complaints related to the environment, communication and monitoring of socio-economic indicators.

6.8.2 Displacement of hamlets

The hamlets located on the site of the works will be moved. Any population displacement is considered a very complex process because you have to ensure the continuity of the population's livelihood. The team in charge of Communication and Social Affairs will be responsible for directing and overseeing the displacement program of these hamlets. This will receive the ongoing support from the highest hierarchy of the company.

A displacement plan of these settlements will be prepared by a specialist as soon as the operating authorizations are obtained. The displacement will be a participatory process that includes the establishment of an advisory committee, as well as communication and arbitration between the company and the affected people.

6.8.3 Farm compensations

The main objective of the compensation program is to minimize the company's impact on the land and pay adequate compensatory amount to individuals who have suffered a loss of earnings.

The names of the affected people, land surfaces and compensatory amounts paid will be carefully recorded in a register provided for that purpose. The compensation process will be done with the assistance of agricultural services according to the Ivorian regulations (see Interministerial Order No. 28 MINAGRA / MEF of 12 March 1996 laying down the scale of compensation for crops destroyed).

6.8.4 Information meetings with the community

Perseus Mining is aware of the importance of maintaining an ongoing dialogue and good relations with local populations and authorities. Information meetings will be organized regularly with traditional authorities, representatives of government departments and people to ensure good communication and cooperation between the different parties. A standing advisory committee will be established for this purpose with a representative of all parties concerned. The terms and subject meetings will be established in due course. The frequency of meetings will be at least quarterly.

6.8.5 Participation in community development

The company will work closely with local authorities to identify local projects for community development to be funded through the "social development fund " .The type of project that will be considered may include (depending on available budgets):

- rehabilitation of communication routes;
- rehabilitation of health centers, schools, youth centers, etc. ;
- any other project to be considered plausible and feasible by the company.

6.8.6 Monitoring of socio-economic issues

This part of the environmental monitoring plan will include the following activities:

- monitoring of relevant socio-economic indicators (employment, population and immigration, infrastructure development, etc.);
- Monitoring of potential disruptive elements of the social environment (traffic, deterioration of surface water, noise, etc.).

All data will be recorded in files.

6.9 WASTE MANAGEMENT

6.9.1 Overview

The development and operation of the Sissingue project will generate several categories of waste, in this case the mine waste (tailings) and non-mining waste such as household solid waste, ordinary industrial waste, special industrial waste (including used oil and oil filters) and laboratory waste. All aspects of management will be closely monitored by the Environment Department.

6.9.2 Basic principles of waste management

Waste management will be done in accordance with the legislation in force, including nº96-766 Act of October 3, 1996, with the environmental code.

The major waste management principles to be adopted by Perseus Mining are:

- regularly updating the waste management plan;
- minimizing waste generation at all levels;
- wherever conceivable sorting and recycling waste;
- eliminating waste that cannot be avoided by the most appropriate and economically acceptable method for the type of waste;
- seeking collaboration with other industry operators;
- ensuring that contractors have been informed of their waste management liability.

6.9.3 Tailings and Acid Potential

The Mining Department will keep a data register of quantities of waste generated throughout the span project. The environmental staff have the responsibility to monitor how the TSF will be built, as well as managing the mining department and its contractors.

During the operational phase, it will be necessary to carry out regular monitoring to include:

- a quality control runoff from areas of the TSF. Visual observations and a pH meter will already understand the problem;
- reiterate the potential of acid tests of tailings.

6.9.4 Other categories of waste

Management and mode of disposal of other categories of waste (municipal solid waste, ordinary industrial waste, industrial waste and laboratory waste) were discussed in detail in section 5.0.

The environmental staff will be responsible for the management of waste through the implementation of a waste management plan, ensuring compliance of subcontractors with the management guidelines, encouraging recycling and inspecting landfills, etc.

6.10 REHABILITATION AND CLOSURE PLANS

The plans for rehabilitation and mine closure are dynamic documents prepared separately at different life stages of a project. They are integrated in the environmental management plan for the following reasons:

- rehabilitation of a site is a dynamic activity that begins in the early years of commissioning of facilities;
- rehabilitation is the responsibility of environmental staff although its implementation involves several departments (mining, processing, maintenance);
- the site closure plan is only conceptual, during the first years of the project, but it shows the major choices in becoming the project works and presents the information necessary to develop an appropriate rehabilitation strategy (including the costs).

A preliminary plan for rehabilitation and site closure is presented in Chapter 7.0.

6.11 HEALTH AND SAFETY

Occupational health and safety will be included in the Environmental Management Plan.

The main aspects of occupational health and safety will be developed along the lines presented in Chapter 8.0. Occupational health and safety will be managed separately within the Environmental Department.

6.12 EMERGENCY RESPONSE PLAN

An emergency response plan will be prepared from the start of operations. This plan is not necessarily detailed in the Environmental Management Plan but emergency prevention, preparedness, response and recovery can be included. Key aspects of the plan are presented in Chapter 8.0.

6.13 AUDIT OF OPERATIONS

Internal and external environmental auditing procedures and regulations will be developed in order to verify the compliance of the company and employees to national legislation but also the company environmental, health and safety policies and procedures.

An environmental audit carried out by independent consultants appointed once every three years in accordance with Decree No. 2005-03 of 6 January 2005 on the environmental audit.

6.14 MATRIX OF ENVIRONMENTAL MONITORING PLAN

The matrix of environmental monitoring plan includes a list of environmental actions to be performed for the duration of the project. This plan establishes environmental indicators for monitoring of project mitigation measures. Moreover, institutions that will be involved in this phase were identified as well as the costs for the environmental monitoring.

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementin	Responsible for monitoring	Monitoring Method	Cost (US$)	Funding source
P	Documentation	Environment	Update of the Environmental Monitoring Plan		ANDE		TBD	Perseus-operational budget
	Movement of vehicles on roads	Dust formation	A tanker truck disperses water evenly on the tracks and the access road	Sub-contractor	ANDE	Visual monitoring	US$ 150 per day	Perseus-operational budget
			Vehicle speed will be regulated by the installation of signs	DD	ANDE	Visual monitoring	US$ 1500	Perseus-operational budget
			Instructions are inserted into specific clauses in contracts to subcontractors.	Director of the Mine, General	ANDE	Visual monitoring	Good management	-
			Bare surfaces will be kept to a minimum, especially in the workspace. Bare areas will progressively grassed.	Subcontractor	ANDE	Visual monitoring	Included in the costs of the mine	Perseus-operational budget
	Site preparation and surface blasting	Poor quality of surface water	Sedimentation basins will be built at the lowest point of the site of the processing plant and ore storage. The edges will be planted with grass or riprapped	Sub-contractor	ANDE	* Quality of Bagoé river downstream (pH, OF), visual inspections	US$ 5000 for construction e t Environment Budget for monitoring (US$	Perseus - investment budget Perseus-operational budget -

	Machine use in site preparation	Poor quality of surface water	As a safeguard, the company will introduce requirements to protect and respect the environment in the contracts of subcontractors. It will be stipulated for example to use well-maintained vehicles, storing hydrocarbons on appropriate retention areas or to clean up a site Accidental pollution caused	Director of the Mine, General Director	ANDE	* Quality of Bagoé river downstream (oils and fats), visual inspections	Good management and environment procedure (US$ 250 000/year)	Perseus- operational budget -

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementin	Responsible for monitoring	Monitoring Method	Cost (US$)	Funding source
Période de Construction	Site preparation	Poor quality of surface water	Domestic effluents from toilets will be drained into septic tanks.	Sub-contractor	ANDE	*Qualité du fleuve Bagoé à l'aval (pH, MES, DCO, DBO,	US$ 15000 pour la construction e t Budget pour le suivi	Perseus-investment budget
	Accident al discharg	Poor quality of surface water	Construction of retention zones to the treatment plant.	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
	Hydrocarbon leakage into the environment	Poor quality of surface water	Each tank containing hydrocarbons will be built on a concrete containment area that will hold the volume of at least	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
			The drums containing oils will be stored on an impervious area.	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
			The workshops will be constructed on an impervious surface for directing all losses to a recovery pit leading to a hydrocarbon separator.	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
	Clearing the ground for works	Disruption of hydrological regime	The design and construction of the project works include the installation of a network of diversion ditches, drainage channels, sedimentation basins, culverts, etc. to minimize the negative effects of increased	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
	Construction of TSF	Seepage from tailings	A recovery system filtering water will be installed at the base.	Sub-contractor	ANDE	Compaction test	Included in construction costs	Perseus-investment budget

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for Implementatio	Responsible for monitoring	Monitoring method	Cost (US$)	Source of
Période de Construction	Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast).	Deforestation sites will be selective and gradual. Wood obtained will be donated to local populations.	DD	ANDE	Visual inspections	-	-
			Before any surface preparation work, the topsoil will be identified and recovered to be used for rehabilitation purposes.	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
	Influx of population in the project area	Indirect effects on the ecological	The inclusion in contracts of employees and subcontractors of a clause prohibiting hunting on the entire license area.	Director of the Mine, General Director	ANDE	Inspections	Good management procedure	-
	The various activities of site preparation and the exposure of large areas of land	Soil erosion	Limit deforestation and surface blasting to the minimum required	Sub-contractor	ANDE	Visual inspections	Good management	-
			Early revegetation of stripped sites and use of anti-erosion materials	Sub-contractor	ANDE	Visual inspections	Included in construction costs	Perseus-investment budget
	Development of project works and road construction	Destruction of farms	Farmers with fields and crops and the landowners affected by the project activities will be financially compensated according to regulations. An accurate assessment of fields and crops will be carried out during the construction period.	DD, Agriculture Services	ANDE	Number of complaints.	TBD by Displacement Plan	Perseus-investment budget
			Prior to construction, the area and the influence of the works must be accurately known to avoid massively destroy crops.	DD, Director of the Mine	ANDE	Reducing the project footprint	Good management procedure	-

	Activity/Source of impact	Impact identified	Mitigation Measures	Responible for Implementation	Responsible for Monitoring	Monitoring Method	Cost (US$)	Source of funding
Période de Construction	Creation of new jobs	Training and employment	Young people from the project area and the region will be used in priority after a selection based on the general suitability of the person.	Director of Mine, Employment Services	ANDE	Statistics	Good management procedure	-
	Development of various project works	Displacement of the population in nearby hamlets	A displacement plan (physical and / or economic) will be prepared by a specialist.	Consultant, DD	ANDE	-	US$ 60 000	Perseus-investment budget
			Displaced persons will be compensated financially.	Sub-contractor, DD	ANDE	Number of complaints		
	Development of the gold mine	Massive influx of population	As a social partner, the company is committed to maintaining dialogue and contact with government and	DD, Director of the Mine	ANDE	Immigration and employment statistics	Good management procedure	-
			Construction of an enhanced village water system (HVA) to increase the current capacity to supply Sissingue	Sub-contractor	ANDE	-	TBD after the study	Perseus-investment budget
	Development of the gold mine	Weakening of social power	For the consultative process to be effective, the rule of Sissingue village leader will be recognised. Also local recognition of the land chief is needed to strengthen social cohesion. Any decision must be collegial	DD, Director of the Mine	ANDE	Number of complaints	Good management procedure	-

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for implementati	Responsible for monitoring	Monitoring Method	Cost (US$)	Source of funding
Période de Construction	Development of the gold mine	Disappearance of sacred sites or burial sites	Concerned villagers may participate in the implementation and monitoring of site protection measures and ensure, wherever possible, access to the site at all times.	DD, villagers	ANDE	Number of complaints	Good management procedure	
	Construction of the ore processing plant	Disappearance of sacred sites or burial sites	Moving the sacred Navigo site on the area required for the development of the gold project	DD, villagers	ANDE	-	US$ 3 000	Perseus-investment budget
	Operation and servicing of the site	Non-mining waste	Preparation of a waste management plan	DD	ANDE	-	Salaire DD	Perseus – operational
			Construction d'une décharge au sein de la verse à stérile.	Mining Departmen	ANDE	Visual inspections	Operational costs	Perseus-operational

* The quality of wastewater, wells and surface water used as drinking water will comply with:
* World Bank and WHO Standards
• The quality of surface water will not be worse than that established during the initial state.

ANDE : Agence Nationale de l'Environnement (National Environment Agency)

DD : Sustainable Development Staff

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for implementati	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des Opérations	Earthworks	Degradation of the	Reducing logging to the minimum required and increading awareness of workers and local	DD	ANDE	-	Good management	-
	Ore crushing	Dust formation from fixed sources	Masks for protection against dust will be distributed to the workers.	Département Procédé	ANDE	Dust measurement, number of respiratory diseases	Coût de Santé et de sécurité au travail	Perseus-operational budget
	Combustion ovens	Dust formation from fixed sources	Installation of a chimney at the highest point of the plant	Département Procédé	ANDE	Dust measurement, number of respiratory diseases	Included in construction costs	Perseus-investment budget
	Movement of vehicles on dirt tracks	Dust formation from diffuse sources	Limiting traffic speeds and regular watering of tracks by water tankers. The frequency of watering will depend on weather conditions and tracks attendance.	Mining Sub-contractor, DD	ANDE	**Dust measurement, Visual Inspection	US$ 300 per day	Perseus-operational budget
	Working with explosives	Dust formation from diffuse sources	The use of an explosive system that could reduce the emission of dust. The explosion areas will be minimized and the wind direction will be controlled.	Mining Sub-contractor	ANDE	**Dust measurement, Visual Inspection	Included in the budget of the mine	Perseus-operational budget
	Wind on surface	Dust formation from diffuse sources	Bare surfaces are watered regularly during dry periods to prevent dust.	Mining Sub-contractor, DD	ANDE	Visual inspections	Included in the budget of the mine	Perseus-operational budget

	Activités/Sources d'impact	Impact identifi	Mesures correctives et préventives	Responsable de	Responsable du suivi	Indicateur de suivi	Coûts	Sources de financemen
Période des	Diesel engines	Production of greenhouse gases	Selection of diesel vehicles using quality products; development of a preventive maintenance program; immediate repair of vehicles and regular review of vehicle breakdowns	Mining Sub-contractor	ANDE	Visual inspections	Operational costs	Perseus-operational budget
	Laboratory analyses	Gas emissions	Installation of laboratory extractors equipped with fume recovery filters.	Laboratory	ANDE	***Medical examination of	US$ 200/month for the filters and US$ 150/month for medical exam	Perseus-operational budget
	Crushers, processing plant and mining equipment	Continuous noise	Every worker in will receive hearing protection helmets.	Department Process	ANDE	**Noise measurement, Hearing	Included in OHS Budget	Perseus-operational budget
			Making noise measurements for identification of potential impact. Build sound barriers if necessary to protect the surrounding population.	DD,Mining Sub-contractor	ANDE	Noise measurement, Visual inspections	Included in the costs of construction	Perseus-investment budget
	Work with explosives in the three quarries	Noise and vibrations	To minimize the surprise of detonations on people, the company will ensure that the explosion hours will be communicated in advance to the inhabitants of Sissingue, as well as local residents	Mining Department, DD	ANDE	Number of complaints	US$ 400 to warn the community	Perseus-operational budget
			Using modern techniques with explosives by a competent contractor with experience in the subregion.	Mining Department, DD	ANDE	Number of complaints	-	Perseus-operational budget

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for implementatio	Responsible for monitoring	Monitoring Method	Cost (US$)	Source of funding
Période des Opérations	Adding a third crusher	Increasing the amount of dust on the plant site	Using protective masks against the dust	Departmen t Process	ANDE	Dust measurement , number of respiratory diseases	Part of the environmental management budget	Perseus-operationa l budget
	Construction of the WWTP	Increasing the amount of dust on the plant site	Surfaces regularly watered to reduce air emissions	Mining Sub-contractor, DD	ANDE	Dust measurement , number of respiratory	Part of the environmental management budget	Perseus-operationa l budget
	Construction of the airstrip	Increasing the amount of dust on the plant site	Surfaces regularly watered to reduce air emissions	Mining Sub-contractor,	ANDE	Dust measurement , number of respiratory	Part of the environmental management budget	Perseus-operationa l budget
	Takeoff and landing of aircraft on the runway	Increased level of noise	Establishment of a complaints management plan related to noise on the runway. Using protective	Departmen t Process	ANDE	Number of complaints, noise measurement	Part of the environmental management budget	Perseus-operationa l budget
	Operation of the camp and administration	Increased organic matter in surface water, soil infertility, decreased agricultural yields	These effluents will be drained through a sewer system to the treatment plant and undergo several processing steps to meet the discharge standards. Surfaces will be grassed where possible to reduce	Mining Sub-contractor, DD	ANDE	Analysis of the quality of surface water and soil	Part of the environmental management budget	Perseus-operationa l budget

	Activity/Source of impact	Impact identified	Mitigation Measures	Repsonsible for implementat	Responsible for monitoring	Monitoring Method	Cost (US$)	Source of funding
Période des Opérations	Work with explosives in the three quarries	Noise and vibrations	The vibrations generated by blasting with explosives could create cracks in the buildings of the villages mentioned above. Therefore, the buildings structural conditions will be regularly monitored and photos will be taken as supporting evidence.	Mining Department, DD	ANDE	Number of complaints	-	Perseus-operational budget
			During each explosion, noise and vibration levels will be measured at about 500 m from the quarry.	DD	ANDE	**Noise and vibration measurement	Environment-equipment budget (US$ 73 000) and (US$ 250 000 per year	Perseus-investment budget OCG-operational budget
	Clearing the ground for works	Disruption of hydrological regime	The design and construction of the project works include the installation of a network of diversion ditches, drainage channels, sedimentation basins, culverts, etc. to minimize the negative effects of increased runoff coefficient	Mining Department, DD	ANDE	Observation of the flow of Bagoé river	Environment budget (US$ 250 000/year)	Perseus-operational budget
	Pumping water to fill the water balance deficit	Disruption of hydrological regime	Pumping water from the Bagoé will be restricted to rainy periods. When pumping water from the side of the left bank of the Bagoé owned by the Republic of Côte d'Ivoire, the company will send a request to	Department Process	ANDE	Observation of the flow of Bagoé river in the dry season	Environment Budget (US$ 250 000/year) and operation costs	Perseus-operational budget

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for implementatio	Responsible for monitoring	Monitoring Method	Cost (US$)	Source of funding
Période des opérations	Water discharge from the mine due to heavy rain	Disruption of hydrological regime	Conserve this water and reuse it to water the access road and the tracks inside the mine.	Mining Departmen t, DD	ANDE	Visual inspections	Environment Budget (US$ 250 000/year)	Perseus-operationa l budget
	Accidental discharge of effluent following the drilling of a pipe, hose rupture, etc.	Poor quality of surface water	Regular inspections of pumps, pipes, tailings dam and the seepage collection pond will be conducted by the department in	Process Departmen t	ANDE	*Quality of the Bagoé river (pH, conductivity, cyanides and heavy	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operationa l budget
			Accidental spills with cyanides, calcium hypochlorite will be available to detoxify the area that was accidentally contaminated	Process Departmen t	ANDE	* Sediment quality or water that may be affected	Environment Budget (US$ 250 000/year)	Perseus-operational budget
			Preparing an emergency plan including prevention and monitoring the integrity of the TSF.	Process Department, DD	ANDE	Zero accident Category 1	Salary	Perseus-operational budget
	Water discharge into the environment in case of heavy	Poor quality of surface water	Water discharges from the mine will be done in a controlled manner. Their quality will be continuously monitored.	Mining Department	ANDE	Visual inspections	Environment Budget (US$ 250 000/year)	Perseus-operationa l budget
	Oxidation of sulfur rock and acid drainage	Poor quality of surface water	During operation, the acid potential tests will be performed regularly on samples of tailings and ore during their extraction. If a problem occurred it is still possible to take appropriate measures such as encapsulation of reactive	Mining Department	ANDE	Visual inspections, *Quality of the Bagoé river (pH)	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operationa l budget

	Activity/Source of impact	Impact identified	Mitigation Measures	Responsible for implementation	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des opérations	TSF and other project areas	Poor quality of surface water	The quality of surface water at the basins will be monitored regularly by the environment department.	Mining Department	ANDE	*Quality of Bagoé river (pH, MES)	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
			Early rehabilitation and revegetation sites and exposed areas will be systematically	Mining Department, DD	ANDE	Visual inspection of major erosion	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
	Domestic effluents and contents of septic tanks	Poor quality of surface water	Domestic effluents from camp and other sites' toilets will be drained in septic tanks.	Maintenance Department	ANDE	* Quality of Bagoé river (pH, MES, DCO, DBO, Coliforms)	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
	Domestic effluents and contents of septic tanks	Poor quality of surface water	When septic tanks are filled mining company Perseus Mining will contact a company responsible for the management of waste water disposal according to Ivorian procedure.	Sub-contractor DD	ANDE	Quality of Bagoé river (pH, MES, DCO, DBO, Coliforms)	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementation	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des opérations	Hydrocarbon leakage into the environment	Poor quality of surface water	The fat accumulated in these systems will be eliminated by the supplier of petroleum products in an appropriate site.	Sub-contractors of petroleum products, All departments using hydrocarbons	ANDE	Quality of the Bagoé river downstream (oil and fat), Visual Inspections workshops/ storage	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
			Each tank containing hydrocarbons will be built on a concrete containment area that will hold the volume of at least one tank in case of breakage.	Sub-contractors of petroleum products, All departments using hydrocarbons	ANDE	Quality of the Bagoé river downstream (oil and fat), Visual Inspections workshops/	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
			The drums containing oils will be stored on an impervious area.	Sub-contractors of petroleum products, All departments using hydrocarbons	ANDE	Visual Inspections workshops/ storage	Environment Budget (US$ 250 000/year) and operating costs -	Perseus-operational budget
			As a safeguard, the company will introduce requirements for the protection and respect of the environment in the contracts of subcontractors.	Sub-contractors of petroleum products, All departments using hydrocarbons	ANDE	Quality of the Bagoé river downstream (oil and fat), Visual Inspections workshops/	Environment Budget (US$ 250 000/year) and operating costs	Perseus-investment budget – Perseus operational budget

	Activity/ Source of impact	**Impact identified**	**Mitigation Measures**	**Responsible for implementatio**	**Responsible for monitoring**	**Monitoring Methods**	**Cost (US$)**	**Source of funding**
Période des opérations	Transport (Chemical spills)	Poor quality of surface water	A good convenient transportation and handling of these chemicals should be taught to officers committed to the task. Effective and immediate cleaning of spills. Transporting chemicals only during the day.	Sub-contractors of chemical products and all departments using chemical products	ANDE	* Quality of the Bagoé river downstream, Visual Inspections workshops/ storage	Including in the processing cost	Perseus-operational budget
	Pumping for potable water	Poor quality and decrease in the amount of groundwater	Install an electric pump whose pumping rate will not be higher than the drilling. That is to say, an adequate volume of good quality water according to the operating	DD, Process Department	ANDE	Visual inspections		Perseus-operational budget
	Seepage from tailings	Poor groundwater quality	Sampling of observation wells downstream of the TSF.	DD, Process Department	ANDE	Quality (pH, conductivity, cyanides, heavy metals and major	Environment Budget (US$ 250 000/year)	Perseus-operational budget
			Construction downstream of the dam of the observation wells and pumping water to the tailings or to the ore processing plant to be used in the process.	DD, Process Department	ANDE	Quality (pH, conductivity, cyanides, heavy metals and major	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
	Takeoff and landing	Risk of accidents by hitting birds or mammals	Fully fenced mining area. Setting up a barrier plan	DD, Process Department	ANDE	Number of accidents	Part of the Environmental Management Budget	Perseus-operational budget

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementatio	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des opérations	Seepage of chemical products	Poor quality and decrease in the amount of groundwater	A good practice of transport and handling of these chemicals should be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effective and immediate cleaning should be carried out. Transporting chemicals during the	Sub-contractors of chemical products and all departments using chemical products	ANDE	* Quality of the Bagoé river downstream, Visual Inspections workshops/ storage	Operating costs	Perseus-operational budget
	Development of quarries, TSF and treatment plant	Fragmentation, destruction, loss of habitats of rare species (Ivory Coast)	Site rehabilitation activities will be initiated from the beginning of operations and will include the replacement of rare species. Regular updates of the rehabilitation plan and costs (every three years)	DD, Mining Department	ANDE	General observations of wildlife, (Improvement or no significant deterioration)	Environment Budget (US$ 250 000/year) and operating costs	Perseus-operational budget
		Pollution (noise, dust and waste) from mining activities	Measures to limit noise, dust formation or lack of effluent discharges containing cyanides, are presented in the previous sections. These measures will contribute positively to the reduction of impacts on wildlife	DD, Mining Department	ANDE	General observations of wildlife	Environment Budget (US$ 250 000/year)	Perseus-operational budget
		Holes and ditches	All holes and ditches will be closed gradually. The trenches will be inclined to allow the animals to get out.	DD, Explorartion Department	ANDE	Visual inspections	Included in mining budget	Perseus-exploration budget

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementati	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des	Influx of population in the project area	Indirect effects on the ecological environment	On site monitoring of hunting will be performed by employees who travel frequently on different roads in the	DD	ANDE	General observation of wildlife	Environment Budget (US$ 250 000/year)	Perseus-operational budget
			The display in various locations in the future posters wealth of animal and plant species considered "rare" or vulnerable.	DD	ANDE	General observation of flora and fauna	Environment Budget (US$ 250 000/year)	Perseus-operational budget
			The environmental training course, which will be provided to all employees, include a module	DD	ANDE	Ongoing tests	Included in operating costs	Perseus-operational budget
	The various activities of site preparation and the exposure of large areas of land	Soil erosion	Regular monitoring of the effectiveness of measures and techniques adopted by visual inspection and determination of suspended solids in surface water during the wet season.	DD, all Departments	ANDE	Visual inspection of erosion, Quality of Bagoé river (pH)	Environment Budget (US$ 250 000/year)	Perseus-operational budget
	Poor handling or accidental release of hazardous chemicals during transport	Soil contamination	Good practice of handling these dangerous chemicals must be taught to officers committed to the task (transport conditions, unloading and storage). Spills should be reported and effectively and immediately cleaned. Cyanide management should meet international standards.	Sub-contractors of chemical products and all departments	ANDE	Visual inspection of warehouse	Included in the supply cost	Perseus-operational budget

			Appropriate storage facilities for chemicals	using chemical products			Included in construction costs	Perseus - investm ent

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementatio	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des opérations	Development of project works and road construction	Destruction of farms	Farmers with fields and crops and the landowners affected by the project activities will be financially compensated according to regulations.	Consultant, DD	ANDE	Employment statistics	US$ 30 000	Perseus-operational budget
	Payment of taxes	Royalties	This impact will be strengthened through a process of consultation between all the political, social and economic players. The company will comply with the laws in force.	DD, Director of the Mine, Director General	ANDE	Department and municipal statistics (Municipal Infrastructure Development)	TBD	
	Development of various project works	Displacement of the population in nearby hamlets	Displaced persons will be encouraged to participate in training programs for the development of alternative projects and training investment.	Consultant, DD	ANDE	Employment statistics	US$ 30 000	Perseus-operational budget
	Development of the gold mine	Problems associated with development	Continuous dialogue with the social partners and information from mine employees and local populations.	DD, Director of the Mine	ANDE	Basic infrastructure development	Community Communication Budget	Perseus-operational budget

	Activity/ Source of impact	Impact identified	Mitigation Measures	Responsible for implementatio	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période des opérations	Digging of quarries and pits	Destruction of important remains	A specialist of the Institute of Arts and Archaeology of Abidjan will be contacted for extracting remains.	DD, Director of the Mine	ANDE	Visual inspections	US$ 7 000 – operating costs	Perseus-operationa l budget
	Operation and servicing of the site	Non-mining waste	Updating the waste management plan	DD	ANDE	-	DD Salary	Perseus-operationa l budget
			Landfill construction in the TSF.	Mining Departmen	ANDE	Visual inspections	Operating costs	Perseus-operational budget
	Development of the gold mine	Problem of development of diseases	Perseus Mining will carry out educational and awareness campaigns for employees and community.	DD, Director of the mine	ANDE	Visual inspections	Good operational management procedure and Social	Perseus-operational budget
			Health monitoring program and medical clinic for employees on site.	DD, Director of the mine	ANDE	Visual inspections	Operating budget of health monitoring	Perseus-operational budget
			Food hygiene inspections (eg practices and food handling equipment)	DD, Director of the mine	ANDE	Visual inspections	Operating budget of health monitoring	Perseus-operational budget

	Area	Component	Mitigation Measures	Responsible for implementation	Responsible for monitoring	Monitoring Methods	Cost (US$)	Source of funding
Période de la fermeture	General	Documentation	Updating the mine closure plan	DD, Mining Department	ANDE	-	Operating costs	Perseus - Closure budget
	Landscape	Slopes and flood plains	Implementation of the final closure of the program and rehabilitation and revegetation of stripped areas.	DD, Mining Department, sub-contractors	ANDE	-	Rehabilitation and closure budget	Perseus - Closure budget
	Management of the area	Farms	Site rehabilitation activities will be conducted with the aim to restore the area. The expected results will not be immediate and it will take between 5 and 10 years for the land to be fertile again.	DD, Mining Department, sub-contractors	ANDE	Plant growth, return of wildlife	Rehabilitation and closure budget	Perseus - Closure budget
		Projects	Site restoration project for activities such as aquaculture	DD, Authorities	ANDE	Level of interest by local population	Rehabilitation and closure budget	Perseus - Closure budget
	Environ-ment	Areas	Monitoring the stability of the site by measuring various environmental parameters (quality of surface water and groundwater, erosion, wildlife). Water analysis from TSFand transmission of results to the ANDE before discharge into the environment during the closure phase	DD	ANDE	Visual inspection of maojr erosion, *quality of the Bagoé river, plant growth, return of wildlife	Rehabilitation and closure budget $	Perseus - Closure budget
	People	Security	Making the site secure	DD, sub-contractors	ANDE	No incidents	Rehabilitation and closure budget	Perseus - Closure budget

7.0 PRELIMINARY PLAN FOR THE REHABILITATION AND CLOSURE OF THE SITE

7.1 INTRODUCTION

Mining has resulted in a local modification of vegetation and soil profile, which can cause major changes in the topography of the site.

The legislation of Côte d'Ivoire, like that of many countries provides for stopping mining operations and site rehabilitation. According to the Mining Code, any holder of a mining title must prepare and submit a full environmental impact study and an environmental management program including a plan for the rehabilitation of sites and their estimated costs before undertaking work.

The Mining Code also refers to the obligation to open a trust account to be used for the establishment of a fund to cover the costs of the implementation of the rehabilitation program and site closure. Article 16, order nº96-600 states that it is necessary to open a fund with the National Investment Bank for each operation. The final rehabilitation program and its cost will be evaluated every three (3) years or at the request of the Directorate of Mines or the environmental administration or the operator, with appropriate revision of annuities. "

Although several articles of the Mining Code refer to the conditions for the rehabilitation program of the mine sites, the legislation gives no indication on the closure objectives of the site and guidance on the use of the site after its closure.

This part of the impact study presents a preliminary plan for rehabilitation and closure of the Sissingue gold project. It indicates the objectives of the company and outlines the directions chosen, for rehabilitation and closure, which will be developed in a document accompanying the Environmental Management Plan.

During the operating phase, the rehabilitation plan will be regularly updated (every three years for costs) and adapted to the conditions and requirements prevailing at that time.

7.2 OBJECTIVES OF THE CLOSURE AND REHABILITATION OF THE SITE

Define clear goals for the closure and rehabilitation of the site is a fundamental point of the rehabilitation plan.

The objectives for the Sissingue mining project are:

- comply with all regulatory requirements;
- rehabilitate the site to obtain a post-mining use to be compatible with the rural vocation of the region;

- remove the risk to security and public safety;
- rehabilitate the site to present the long-term, stable configuration and a favorable surface to a post-mining reclamation;
- develop and implement rehabilitation plans in parallel with the operation of the mine;
- provide the financial means that will achieve the agreed objectives.

To achieve the objectives of closing certain criteria were chosen (**Table 7.1**)

Table 7.1 Criteria for closing the Sissingué Mine

Community Participation		• All stakeholders will be involved in all stages of the design of the closure plan through formal meetings periodically. • Businesses and interested local people will be encouraged to participate in the implementation of the work program closure
Socio- economic Impacts		• The quality of life of those affected, as measured by their living conditions, health services, educational infrastructure and the average income per capita will be measurably higher at the start of mine operations. These improvements will be self-funded and sustainable at the end of the mine operations.
Water resources		• If an impact on water resources is identified, the mitigation program implemented. • If long-term measures are necessary, the treatment methods used will bne passive and self maintained.
Soil erosion		• The amount of suspended sediment runoff from the site works will not be higher than the amount measured at point controls upstream of these works.
Re-vegetation		• Return of potentially farmable land
Landscape		• Visually acceptable.
Physical security of the site		• All holes except for three quarries (3 PIT) will be blocked, trenches closed and quarry secured with a privacy fence
Stability	Waste Rock Dump	• Demonstrate that they were built to be stable.
	TSF	• Demonstrate that the final form can maintain stability.
Residual Contaminatio		• Enable the development of agricultural activities and do not restrict access to the public

7.3 GENERAL REHABILITATION PRINCIPLES

A number of general principles of rehabilitation will be monitored to ensure site remediation that can meet the objectives and criteria defined below:

- preparation of a detailed rehabilitation and closure plan of the site in the first year of operation;
- rehabilitate the site progressively;
- prevent the introduction of plant or animal species that may be harmful;
- re-profiling (low gradient) logged areas to ensure their stability, adequate drainage to minimize erosion, an appearance consistent with the overall appearance of the site, and a surface that can be revegetated (or naturally re-colonized);
- identifying and managing risk areas that may develop long-term toxic properties;
- recover maximum topsoil for use in connection with site rehabilitation activities that will be carried out during operation;
- if the soil will not be available in sufficient quantity, identify and test substrates that will or may acquire similar properties;
- restructuring of the compacted surface horizons to promote natural colonization of vegetation;
- maximum use of local plant species;
- dismantle and remove all the facilities that will not be required as part of a post-mining use and reinstatement, and non-mining waste end exploitation;
- monitor and manage the rehabilitated areas until the vegetation reaches sufficient maturity to not require a particular intervention;
- plastic waste will not be buried in landfill or soil, but will be collected and recycled or incinerated if possible.

7.4 REHABILITATION OF PLANNED TECHNICAL SITES

7.4.1 Rehabilitation

Land will be changed by the construction and operation of a quarry, an ore processing plant and its annexes, a tailings facility, camp dwellings and access roads.

The rehabilitation program will include rehabilitation of units having different characteristics. These units are:

- the quarry ;
- TSF;
- Waste Rock Dump;

- the processing plant and its annexes;
- roads and other infrastructure that have been cleared.

7.4.2 Presentation of rehabilitation techniques

7.4.2.1 Soil amendment

If topsoil cannot be obtained in sufficient quantity, different methods of soil amendment may be considered. This could be done through a contribution or a massive addition of a chemical (eg fertilizers, gypsum) or improving natural fertility (structure and nature) of the surface (eg, manure, sewage sludge, compost). Revegetation could be applied to some surfaces such as the Waste Rock Dump or TSF.

This technique will be considered by the future rehabilitation program but with some caution as at a large scale, it often leads to very high costs.

7.4.2.2 Using topsoil

The spreading of topsoil or soil from the stripped surfaces on revegetated surfaces is a universally recongised rehabilitation technique. The soils may contain seeds and rhizomes that allow re-vegetation on certain sites.

This technique will be evaluated by Perseus Mining but a major drawback is the availability of this material at the rehabilitation phase. The amount and quality of the soil will depend largely on what may be retained during the operational phase. Generally, the soil loses its properties if it is not used in a period of about six to twelve months after its recovery. However, this technique should not be excluded from the outset. Even if the soil has lost its biological properties, it may largely retain its physical properties.

7.4.2.3 Direct establishment of vegetation

Establishment of vegetation is one of the most important aspects of the rehabilitation program. Indeed, this technique is often inexpensive and works well especially in tropical areas (where soil alteration phenomena are fast), on surfaces that have been previously stabilized and not subject to a significant erosion phenomenon. Before establishment of vegetation, these surfaces should generally be re-profiled and unstructured surfaces compacted. In the case of the Waste Rock Dump, it has become common to spread on the surface of the finished work a layer of 50 cm thickness of a substrate made of deep soil or sterile oxidized material.

Plant species such as legumes are used to bring the substrate to the beginning of fertilization. These legumes, once planted with little nutritional value as fertilizer, fix nitrogen in the soil and promote the process of natural re-colonization of the seeds. It is also possible to envisage the use of other species known to present no risk of flooding and to give very good results. These include Vetiveria zizanioides (erosion control), and legumes found in the subregion (Terminalia superba, etc.).

This rehabilitation technique can be tested in the TSF or Waste Rock Dump area.

7.4.3 Production of plant material

The establishment of a nursery will be considered from the start of the operational phase. External partnership would also be considered particularly with the Forestry Development Corporation (SODEFOR). The partnership of SODEFOR is not mandatory if Perseus Mining Ivory Coast has internal qualified personnel.

This nursery will produce plant material for research activities in the rehabilitation of various units identified in paragraph 7.4.1 (testing plots), but also to obtain enough plants for erosion control and for the revegetation of various site areas.

The plant material may be produced from cuttings, seeds (bought or collected in the forest) that often require prior treatment (heating, smoking, etc.). A manual will be prepared by the environmental staff.

7.4.4 Establishment of plant material

The establishment of plant material on a previously prepared surface will be achieved by:

- Manual planting of small seedlings or cuttings; and
- Manual or mechanical dispersion of seeds.

Seeding by hydraulic projection is an expensive technique that may not be suited to the conditions of the project area.

7.4.5 Tests and experimentation of techniques

Conducting tests and a summary of the various techniques and types of plants on the sites to be rehabilitated will be an important component of the rehabilitation program under the supervision of staff.

From the beginning of operations, Perseus Mining Ivory Coast will consider a collaboration with: (1) organizations such as technical services (SODEFOR) who have already gained good experience in tree plantation in Ivory Coast and in the same ecological zone; (2) academic institutions will be closely involved in monitoring this program of rehabilitation and (3) other stakeholders, including people who may be employed either in the local production of plant material either as labor.

Perseus Mining Ivory Coast will choose the kind of collaboration, but it is most important to perform technical tests and experiments for crop production.

7.4.6 Erosion control

Erosion control is an important part of the rehabilitation plan. Without control during the construction phase, there can be no sustainable rehabilitation of the site. Among the major erosion control principles the following are the most important:

- limit the destruction of the savannah and stripping surfaces to a minimum;
- perform soil protection measures against erosion on river banks;
- apply appropriate management of natural flows and isolate stripped areas by the construction of diversion ditches for runoff;
- limit the slope of the works and the impact of rain on the soil;

- compaction and reprofiling (contours) areas or structures that must remain etched;
- Early revegetation of stripped areas;
- regular monitoring of the effectiveness of measures and techniques adopted by visual inspection and measurement of suspended solids in surface waters.

7.5 CLOSURE AND REHABILITATION PRESENTED SITE BY SITE

7.5.1 Introduction and objectives

Perseus Mining Ivory Coast will prepare a closure plan that will meet the terms of the mining agreement established as part of the operating license and the requirements of the Mining Code. At the end of production, the future of all buildings, vehicles, small infrastructure (eg fuel tanks), etc. depends on the terms of the mining agreement. The Mining Code states that "buildings, outbuildings, wells, galleries and generally all works permanently installed for operation are left of right by law to State in accordance with environmental management program and rehabilitation of mined sites. "

To achieve the objectives and criteria mentioned above, the closure plan will detail the following:

- proper and safe disposal of all toxic materials, equipment and metal structures;
- decontamination of processing units;
- ensuring that the different sites are without risk to security and public safety;
- rehabilitating the site to present the long-term, stable configuration and a favorable surface to a post-mining recovery

7.5.2 General site

At this stage of the project, it appears that the quarry will leave an opening with an area of about 59 ha to develop, and some 501 hectares of land to be rehabilitated by reprofiling and revegetation.

To fulfill the objectives mentioned in paragraph 7.2 and in particular in relation to the rural vocation of the region and the type of soil, the site of Sissingue could be rehabilitated so as to become an agro-forest area. Indeed, the land use study indicated that there was strong pressure on agricultural land. However, the final fate of the site depends on consultation with communities and other partners.

7.5.3 Quarry

Considering the presence of aquifer, the level of precipitation, surface water intake upstream and the final geometry of the quarry, it is very likely that it will be created with the possibility of overflowing into the natural environment. Currently, this option is the most commonly chosen in the mining industry because it keeps the rocks containing sulfides, in adverse conditions to their oxidation and thus avoid a potential pollution problem.

Information and additional studies are needed to determine the exact terms of rehabilitation of three quarries, possible fluctuation of water levels and quality. At first glance, the quarry can be used as breeding area for fish or water reserve for irrigation and livestock.

The closure and rehabilitation of the quarry may include (depending on its final mission) stages presented as follows:

- partial re-profiling to create a "bank" with, if necessary, an outlet that will direct the overflow of quarry water to the natural environment;
- create favorable conditions to natural colonization of the perimeter or higher career tiers;
- fencing (earth embankment) will be installed in potentially hazardous locations along the perimeter of three quarries.

7.5.4 Waste Rock Dump

For the duration of the project, a large volume of waste will be deposited forming a final area of approximately 153.46 hectares.

Construction and proper management of the Waste Rock Dump, during operation, will greatly reduce the effort it will need to invest to rehabilitate. Responsive design will begin rehabilitation in the early years of operation. In general, the rehabilitation is expected to require :

- reprofiling of slopes and its surface that is compatible with the revegetation activities (Average slope which ensures stability, adequate drainage, etc.);
- cover of a substrate (soil or other materials) areas which present an inconsistent surface with replanting or natural recolonization. At the end of production or construction of part of the TSF, this substrate will be distributed in a layer 50 cm thick on the revegetated surface;
- planting on the surfaces of most appropriate plant species.

7.5.5 TSF

The TSF will have a final area of approximately 58.82 hectares. The stages of closure and rehabilitation are presented below and include a number of activities to be conducted preferably during the dry season:

- At the end of operation, the surface will be very small. After confirming that its quality meets the environmental standards, the water will be directed to the environment downstream over the spillway. The surface of the tailings is well drained;
- All pumps and pipes will be removed from the site;
- Partial re-profiling of the surface may be necessary to prevent stagnant water bodies other than the lake;
- topsoil will be distributed over the surface only if revegetation tests, performed during operation, prove that the establishment of direct technical plant species (with possible accompanying fertilizer and topsoil at the foot each plant) is inappropriate. Whatever the rehabilitation technique, the entire surface of the tailings will be revegetated. The dam of the tailings facility will also be revegetated.

7.5.6 Treatment Plant and its annexes

The treatment plant and its annexes (workshops, crushing plant and ore storage area, water storage basins and explosives depots), buildings and other structures that will be installed will be reassigned to the State.

All industrial equipment and structures that are not required as part of a post-mining use, including the deposit of explosives, will be dismantled and removed from the site.

Some parts of the treatment plant could be reused for another mining project. All buildings will be left on the site in good condition. Note that the exact fate of equipment must be specified by the mining agreement.

Soils that have been accidentally contaminated will be entrusted to a clean-up service for their processing on the site by the contaminated site.

A slight reprofiling of the site and spreading of topsoil might be necessary before the revegetation stage. All surfaces will be compacted prior to being replanted.

7.5.7 Dam and reservoirs

The retained water will be left in good conditions before being sold to the Government of the Republic of Côte d'Ivoire. It will be left as is or open to allow a continuous flow of water.

7.5.8 Pumping station

The pumping station and pipeline will be left behind, in good condition, to be used for irrigation or water supply. If that is not considered to be adequate by the State of Côte d'Ivoire and the local population, the pumping station and all equipment will be removed and sold or reused as part of another project.

7.5.9 Camp site

The residential village will be in good conditions before being sold to the Government of Côte d'Ivoire.

7.5.10 Roads

The total area of access and ore transport roads will reach nearly 39 hectares. The roads that are not required to monitor the site or as part of a post-mining use, (about 17 hectares of internal roads and the corridor of the pipeline) will be rehabilitated.

The compacted surfaces will be scarified and unless extreme cases (presence of a pest that was introduced) left in a natural state for colonization by vegetation.

7.5.11 Other considerations

The closure plan must consider the socio-economic aspects related to the final judgment of the operation. These issues are not usually addressed at the stage of conceptual closure plan, but when the operation has already been operating for a few years at least. Close cooperation with the competent authorities will be performed. During the period of operations, many programs aimed at improving the local population training level will be established. The type of training provided will be chosen in consultation with stakeholders and its main objective the development of rural projects and crafts.

7.6 MONITORING AND CONTROL OF THE REHABILITATION OF THE SITE

Once the rehabilitation measures and work is completed, a period of approximately three years will be devoted to their control and monitoring (geotechnical investigations, quality of surface and ground water, measuring plant growth, etc). This period may vary depending on the quality of the obtained final result. Involvement of the competent authorities and populations will be very important at this stage.

7.7 MANAGEMENT OF REHABILITATION AND CLOSING PROGRAM

The rehabilitation program will be conducted by environmental staff. Additional staff will be required for the production of vegetations and its transplantation to the areas to be rehabilitated.

The closing program will be led by the Director of the mine.

7.8 COSTS OF THE REHABILITATION AND CLOSING

Providing financial resources for the closure and rehabilitation of the mine, is a very important aspect that must be considered right from the project design stage.

To ensure coverage of the costs of rehabilitation, Perseus Mining Ivory Coast will implement a bank guarantee which can be implemented in case of non compliance by Perseus Mining Ivory Coast of its obligations under the site of the rehabilitation program.

The cost of rehabilitation and site closure will be determined on an annual basis and will be revised based on the evolution of mining activities and the level of achievement of the rehabilitation work performed by Perseus Mining Ivory Coast during the operating phase.

Table 7.2 Coûts unitaires des activités de réhabilitation

N°	Activity	Unit	Cost USD
1	Planting vegetation for erosion control	ha	1 500
2	Planting nitrogen-fixing plant species and other species of trees (including fertilizer and soil around the roots)	ha	2 500
3	Saprolite or land transport to be distributed over a 50 cm thickness	ha	4 000
4	Topsoil transport with a 25 cm thickness	ha	4 000
5	Excavate an area of land to a depth of 30 cm	ha	4 000
6	Surface scarification	ha	2 500
7	Surface reprofiling with a bulldozer	ha	3 000
8	Construction of a protective embankment of 2 m high	m	15
9	Water treatment to reduce concentrations of cyanide	m^3	1’5

Table 7.3 Costs of closure and rehabilitation

Work	Activity	Unit of measure-	Unit	Total
Quarry Total area of 59 ha Circumference of the three quarries 3900 m	Reprofiling 10% of the area for permanent and secure access	5.9 ha	**7**	17'700
	Construction of a protective embankment of 2 m high	3 900.	**8**	58'500
	Planting vegetation for erosion control	5.9 ha	**1**	8'850
	Plant nitrogen-fixing plant species around the perimeter of three quarries	3 ha	**2**	34'500
	Sub total	**-**	**-**	**119'550**
Waste Rock Dump Area 153.5 ha Rehabilitatation surface 143 ha	Reprofiling included in construction costs	-	**7**	0
	Spread a layer of soil to 50 cm on the surface for revegetation	143 ha	**3**	572'000
	Planting vegetation for erosion control	14 ha	**1**	21'000
	Planting nitrogen-fixing or other plant species	143 ha	**2**	357'500
	Sub total	**-**	**-**	**950'000**
TSF Surface 153,5 ha	Reprofiling final 10% of the surface	15,35	**7**	46'050
	Construction of a canal between the lake and the spillway	1 ha	**5**	4'000
	Remove hoses and pumps	-	**-**	20'000
	Final treatment of the residual water	200 000	**9**	300'000
	Distribute a layer of soil 25 cm to the surface on reviews only area (30%)	45.9 ha	**4**	183'600
	Planting nitrogen-fixing plant species	143 ha	**2**	357'500
	Sous total	**-**	**-**	**911'150**
WWTP Surface 32,5 ha Area to rehabilitate 22,5 ha	Decommissioning costs of structures	-	**-**	250'000
	Excavation of contaminated land at a depth of 30 cm on 1.6 ha equivalent to 1.5% of the total area	1.6 ha	**5**	6'400
	Landfilling costs of contaminated material	-	**-**	10'000
	Scarifying the surface	22.5 ha	**6**	56'250
	Distribute a layer of soil 25 cm to the surface on reviews only area (20%)	6.5 ha	**4**	26'000
	Planting vegetation for erosion control (10%)	3.25 ha	**1**	4'875
	Planting nitrogen-fixing and / or other plant species	22.5 ha	**2**	56'250
	Sub total	**-**	**-**	**409'775**
Dam and water reservoirs	Partial development to ensure stability and aesthetics	-	**-**	60'000
	Sub total	**-**	**-**	**60'000**

Table 7.4 Costs of closure and rehabilitation (continues)

Roads Surface 17 ha Surface to rehabilitate 15 ha	Scarifying the surface	17 ha	**6**	42 500
	Planting nitrogen-fixing and / or other plant species	15 ha	**2**	37 500
	Sub total	**-**	**-**	**80 000**
Permanent works	**Return to the government**	**-**	**-**	**0**
Demobilisation	Estimated at 2% of the costs of closure / rehabilitation	2 %	**-**	48460
	Sub total	**-**	**-**	**48 460**
Manage ment	Estimated at 10% of the costs of closure / rehabilitation	10 %	**-**	242 298
	Sub total	**-**	**-**	**242 298**
REHABILITATION AND CLOSURE TOTAL				**2 713 733**
Repairs	Estimated at 5% of the costs of closure / rehabilitation	5 %	**-**	135 687
	Sub total	**-**	**-**	**135 687**
Monitoring and control	Estimed at 350 000 $US per year	2 years	**-**	700 000
	Sub total	**-**	**-**	**700 000**
TOTAL WITH MONITORING				**3 549 420**

8.0 HEALTH AND SAFETY EMERGENCY RESPONSE PLAN

8.1 INTRODUCTION

Like any industrial activity, the proposed project may include exceptional conditions or malfunctions, causing incidents or accidents. These may relate to the safety or health of the operating personnel and the public, and the integrity of the natural environment.

Analysis of past accidents shows that they often result from the combination of minor events, internal causes (e.g. mishandling) and / or external causes (lightning, earthquake, storm, etc.).

Situations that require intervention or emergency measures could result from various events in this case:

- accidents of various natures: handling, road transport (people and equipment), chemical spills or contaminated substances, fires and explosions;
- climate hazards such as storms and floods;
- social unrest

This chapter of the environmental impact study outlines the emergency response plan including specific procedures which will be developed by each department, from the outset of the construction period. This plan includes an inventory of aspects relating to occupational health and safety, an inventory and analysis of the dangers posed by the various facilities in case of accident, an assessment of their likelihood and severity as well as the measures to reduce the probability and effects.

The goal of the company is to excel in the field of health and safety. Each employee must actively support the health and safety policy and implement it in accordance with the following commitments:

- Provide a work place which effectively contributes to the management of health and safety;
- Complete a minimum of health and safety requirements;
- continually seek to improve occupational health and safety performance by using available technology, knowledge and practice management;
- Identify the health and safety risks and implement recommendations to eliminate accidents and illness at work through an organization;
- Develop, implement and continuously improve the health and safety management systems and ensure that the practices are integrated in all units of the company;
- Educate and train all employees and contractors by providing knowledge causing them to be responsible in their area;
- Have sufficient resources to meet the health and safety objectives at the mine;

- Review, monitor and evaluate the performance of health and safety during the operational period to make improvements;
- Communicate and consult all stakeholders on security issues;
- Maintain an effective emergency prevention system to meet the health and safety related effects;
- Implement effective systems to reduce or eliminate the risk of health and safety related to transportation, storage, handling and disposal of hazardous materials.

In addition, the performance standards of Australian OHS include:

- Standard 30 - Limited Space
- Standard 31 - Work At Height
- Standard 32 - Guard and Carrier Safety
- Standard 33 - Lifting and Material Handling
- Standard 34 - Power Isolation
- Standard 55 - Mobile Equipment and Vehicles
- Standard 36 - Hazardous Substances
- Standard 37 - Electrical Safety
- Standard 38 - Pressure Dangers
- Standard 39 - Safeguards against fire

8.2 HEALTH AND SAFETY

8.2.1 Introduction

Aspects relating to the health and safety of employees are considered essential by Perseus Mining Ivory Coast and will be part of the operations of the Sissingue mine. Key issues that will shape the management of health and safety are: the preparation and distribution of safe settlement, training, preparation of manuals related to the security aspects, the development of response procedures and distribution of personal protective equipment, fire fighting, monitoring the health of employees and maintaining documentation of the number, circumstances and the types of accidents.

Perseus Mining Ivory Coast is committed to taking all necessary measures to ensure the safety and protect the health of people working on site or located in its surroundings.

8.2.2 Training

Health and safety training will be provided for the purpose of prevention and intervention. The staff and especially the operators will be trained to recognize hazards, handling chemicals, practice emergency care, developing their personal hygiene and control electrical safety issues, fire, driving vehicles, the lifting or working around heavy machinery operation areas. Special training will be given to operators working with explosives. An employee of Perseus Mining will be responsible for providing ongoing assistance in the form of organization, inspections and training courses.

8.2.3 Regulations, emergency manuals and procedures

Health and safety regulations will be distributed to all employees and contractors. They will be displayed in several places around the site and areas at risk. Manuals and specific procedures will be prepared on all matters relating to health and safety. They will be regularly updated and distributed appropriately. They will include specific equipment manuals, safety data sheets of chemicals, an emergency plan with procedures, etc. Emergency plans are dealt with later in this part of the chapter.

8.2.4 Personal protective equipment

Each employee on site will be required to wear protective helmets and safety boots and safety glasses. Other specific equipment such as masks, ear plugs, isothermal suits, life jackets, trousers with long sleeves, etc. will be distributed depending on the activity of the employee and the workplace.

8.2.5 Fire

Workplaces and the camp will be equipped with regulatory equipment such as fire extinguishers, hydrants, and for smoke detectors. The water required for fire fighting will be pumped from the raw water supply basin. Finally, mobile equipment to fight fire will be located on site. A training program for prevention and rapid response in emergencies and regular inspections will be established and implemented.

8.2.6 First aid and emergency health monitoring

To provide emergency care personnel, the site will have an infirmary. The premises will be equipped with first aid supplies in areas with potential high risk and officers trained in first aid. An ambulance will be permanently stationed on site.

All employees will be regularly checked by a specialist practitioner in medicine and industrial hygiene.

The air quality in the workplace will be regularly measured for concentrations of particular dust. Hdrogen cyanide sensors (gas) will be placed at sensitive points of the gold recovery unit.

8.3 EMERGENCY RESPONSE PLAN

8.3.1 Introduction

The emergency response plan includes a substantial section on alert procedures and responses to emergency. Perseus Mining will establish an emergency plan, which will be communicated to employees of the mine and to the authorities concerned (mining services, the environment and civil protection).

The plan will have the primary objectives:

- monitoring and maintaining constructive and operational arrangements established to limit the causes and effects of accidents due to a failure of one of the works of the project. The environmental staff should be regularly informed of the results of the control and monitoring of these works by the services / departments. It will occur when measuring a particular environmental setting will be monitoring procedures;
- updating and repeated distribution of alert procedures;

- updating and regular testing of the emergency response procedures.

8.3.2 Emergency contact lists

A list of persons and services to contact in case of emergency will be prepared at the beginning of the construction period. This list will be posted at all sites that are potentially dangerous and will be updated regularly.

8.3.3 Categorisation of emergencies and accidents

Emergency situations or types of accidents will be classified according to their nature, severity and probability of occurrence. In the mining sector, accidents are often classified into 3 categories:

- **High risk**: serious accidents that result in death or serious injury of persons, material damage or a high level of environmental pollution outside facilities / structures;
- **Medium risk**: accidents that result in medium injuries to people, property damage or environmental pollution or inside facilities / structures;
- **Low risk**: accidents that result in minor injuries to people, minor property damage or environmental pollution very quickly localized and controlled.

8.3.4 Awareness campaign

Perseus Mining Côte d'Ivoire will initiate an awareness campaign for the local population (population of the village of Sissingue) for an understanding of disaster risk and the necessary arrangements for intervention the emergency. This operation will be led by a Perseus Mining risk specialist. The frequency of this campaign will be defined during the period of operations.

8.3.5 Stages of an alert procedure and intervention

Alert procedures and emergency interventions will be developed as part of the response plan to the emergency, include the following steps:

- verify and assess the severity of the accident (eg leakage, breakage, etc.);
- in the case of a leak, check whether it is confined to a holding area and for how long;
- sound the alarm and / or inform the head of the operational site (depending on the severity of the accident, the mine manager and the Director General shall be notified immediately);
- in the case of a leak, try to stop and / or direct it to an area where it will be contained;
- in case of pollution, clean up the site (eg with calcium hypochlorite if it contains cyanide);
- depending on the nature of the accident, ensure that the employees or the public are not in danger (eg. The users of water resources downstream of a leak must be warned and prevented from using this resource up 'that the situation is under control should also provide an alternative water source).
- conduct an urgent investigation following an incident;
- prepare a written report to the managing director and head of department;

- inform the authorities of the concerned ministries (mining, environment, etc.);
- set up monitoring measures to ensure that the effects or consequences of the accident are under control;
- make technical changes or the training necessary to prevent a recurrence of the problem.

8.3.6 Emergency Evaluation

8.3.6.1 Ore Processing Units

The ore treatment process is designed to operate in closed circuit. The plant will be fully screened with a progressive safety system to limited access to categories of staff and monitored. This plant will include:

- a crushing unit;
- a grinding unit;
- a gold extraction unit of the fine ore that could be described as a system of tanks may contain cyanides;
- a coarse gold recovery unit by gravimetric method;
- a gold recovery unit comprising an electrolysis step and a melting step for obtaining ingots;
- the water tanks to supply the process;
- storage units of the main chemicals (sodium cyanide, lime, hydrochloric acid, sodium hydroxide and calcium hypochlorite)

Ore processing units will be designed to ensure maximum safety and minimize the risk of accidents or leaks that could end up in the environment. Furthermore, qualified personnel will carry out regular inspections of various facilities, which may present risks of leaks or accidents.

All at risk operations will be automated or semi-automated and monitored from a control room that can detect such large variations in pressure in the pipes, the level sensor signal, etc. The preparation of liquid cyanide may be cited from briquettes, transfers of solutions containing cyanide, acid solutions or aqueous solutions, etc. particularly as monitored units.

All areas with fall hazards will have barriers and guard rails. All moving parts (motors, gear) are protected by railings. Leaching tanks and storage containing dangerous substances such as cyanide will be built on a retention zone.

Processed water will be isolated from the rest of the environment by an impermeable membrane in high density polyethylene (HDPE).

Chemicals which may react violently together will be stored separately (cyanide and acids) and on sealed areas to which access is controlled.

Accidents that could occur at the plant's units are generally "localized" such as a pipe or a hose rupture, a leak at a pump, container or valve, an electrical problem, etc.

In general the risks do not contain elements which could lead to a major type of disaster. The system does not contain parts or highly flammable compounds. Cyanides are not flammable.

8.3.6.2 Transport and storage of waste Tailings Pipeline Rupture

The residues are transported in pipelines.

They can be made of steel or HDPE (High Density Poly Ethylene in). They have fixed and moving parts parts to allow the passage of obstacles and the evolution of residue disposal areas.

The case of breach of these pipelines are generally considered known and well controlled. They can be caused by faulty operation of pipelines with heavy machinery or by broken valves or fittings used or incorrectly installed.

These events are generally considered infrequent and of moderate severity because losses are often local (a few hundred m2 affected). Depending on the characteristics of the relevant residues and place of loss, the consequences can be:

- superficial soil pollution (to the extent that the residues have a polluting);
- a temporary surface water pollution (to the extent that the residues have a polluting);
- damage to the vegetation

The potential consequences to public health depend on the exact terms of the loss.

Key measures planned against the risk of incidents include:

- constructive provisions: retention ditches, special protections for crossings backwaters;
- operational arrangements: use of tools adapted for travel, staff specialization, daily monitoring of pipes, automatic device detection losses, etc .;
- means of intervention: preventive settling ponds, earthmoving equipment reduced for recoupment and sent to tailings.

Dike break of TSF

Overview

The tailings proposed for the Sissingue gold project work can be seen as a settling tank whose capacity is created by closing low topographic region by a dike. Residues are often filed by spill from multiple lines on the outskirts of the park to create a peripheral deposit range. At the center of the tailings will be the water for the settling of residues which can thus be partially recycled to the plant from a floating pump station.

The TSF is designed to be stable in the long term and is saturated by the volume of waste and is rehabilitated as is, without major changes in structure.

The main risk is the breaking of the dam restraint which can lead to a spill of tailings and aqueous contents.

It is important to note that, generally, the risk is considered an extremely low probability.

Main causes of breaking dikes

According to the Agency of Environmental Protection Australia (Best Practice Environmental Management in Mining, Tailings Containment, June 1995), the main threats to the stability of a tailings dam are:

- overflow of these dams during an exceptional rainfall event;

- excessive interstitial hydrostatic pressure within the dam resulting from high water surface (which can lead to the base of liquefaction);
- internal erosion of the dike following the infiltrations therein;
- liquefaction of saturated materials of the structure during an earthquake.

Other elements of the design that are justified by the major causes of failure are:

- The structure is located at the head of waterway;
- the slopes of the upstream and downstream facings will be 1V: 3H. These very low slopes provide sufficient mechanical stability;
- these gentle slopes also take into account the high interstitial hydrostatic pressure due to the impermeability of the dam (upper phreatic surface);
- a dimensioned safely spillway is provided at a lower side than the crest of the dam to eliminate any risk of overflow crest dikes in case of exceptional rain;
- a drainage blanket (or filter drain) will be placed at the outer base of the dam and will prevent internal erosion;
- although the project area is in seismic risk zone "0", the slopes will be designed to ensure stability in the case of a design earthquake.

The tailings will be deposited downstream. This allows the gradually strengthening by the deposited tailings.

Proposal for a risk management strategy

Perseus Mining wishes to assure the public and the Ivorian government of risks for the construction of tailings that is consistent with their expectations.

This risk control will apply to the selection of the construction site, selecting the type of structure, the design of the structure, the construction of the structure, operation, its closure and rehabilitation.

In this context, Perseus Mining plans to develop a strategic plan to be decided in consultation with the competent authorities and all other stakeholders that could legitimately be involved in this process. The main components of this strategy are the first approach, the following:

Validation of relevant techniques

Measures such as those discussed below were decided:

- selection of a consulting designer with the experience of several similar works under equivalent conditions;
- requirement of study of similar works in equivalent conditions;

Establishment of a system of management and quality control of the project

Good design is only useful if the implementation, operation, monitoring the work and rehabilitation are carried out with the same level of requirements.

A quality work management plan, inspired by environmental management systems (ISO 14001) and quality assurance (ISO 9000) will be implemented to ensure the quality concerns throughout the life cycle of the structure.

The recommendations of the World Bank will also be introduced in this plan.

Thorough and concerted preparation of emergency
A thorough study of predictive hazard will be considered. It could include in particular:

- a risk analysis of rupture of the tailings facility;
- preparation of a plan to protect, alert and respond in consultation with the relevant services such as civil protection. Such a plan could lead to the specific construction of protective structures (eg wind load), alert (eg. Hotlines) and intervention (ex. Lifeboat).

Intense monitoring of the dam

- visual, piezometric, geotechnical, hydraulic, topographic and photographic monitoring of the work;
- This monitoring will be defined by the designer**.**

Detailed definition of the responsibilities of the individuals involved and verification of insurance and guarantees offered by stakeholders

- the relevant regulations in engineering public works will be observed;
- the contractor shall have no connection with the companies involved directly and will direct the work or appoint an individual responsible for directing the work;
- the head of the work will have no connection with these companies and can approve the plans, check and accept the quality of materials, receive jobs, exclude any person or company for insubordination or failure and order the partial destruction of non-conforming structures and finally to make the operations prior to acceptance of the works;
- Furthermore, insurance commitments and guarantees of the various stakeholders will be checked for their compliance and their technical and financial adequacy to the challenges inherent in the project.

8.3.6.3 Storage and use of hydrocarbons

These industrial operations are generally well regulated and well known to the administration. The most feared accidents are fires and explosions and major losses of fuel or lubricants.

Key features provided by regulations and standards are:

- fire safety perimeters;
- smoking ban and fire permit on the site;
- the grounding of facilities;
- Use of explosion-proof equipment when working on site;
- regular tests on tanks;
- the retention devices at any area of storage and distribution.

Petroleum product providers will be contractually bound to have an emergency response plan to deal with possible leaks or spills that might occur during transportation, distribution or storage of the products concerned.

8.3.6.4 Transport of dangerous materials on the road

Transporting hazardous materials outside the site will be made by suppliers and will not be under the direct responsibility of the operator.

Nevertheless, in connection with the policy of the environmental company, specific clauses will be included in contracts for the supply and subcontracting to prevent hazards that may be associated with these operations.

Outlining requirements for prevention, including specific clauses to complement them where necessary, especially in terms of prevention and intervention in the following cases:

- unloading accident / loading;
- failure of the storage devices during transport
- road accident ;
- cargo flight.

On arrival at the site, the carrier must comply with specific health and safety plan and operations, certain aspects relating to accidental pollution of the environment, are included in the management plan for the environment.

8.3.6.5 Road traffic within the site

It will be necessary to rehabilitate portions of the access road to the project site including strengthening some hydraulic structures crossing the project area. An access road will be built to bypass the village of Sissingue which is currently crossed by the access road to the exploration site.

There are two types of potential road accidents: one resulting in injuries to people and the other involving chemical spills such as cyanides, acids, oils, etc. Note that the most dangerous substances such as cyanide are in solid form and kept in containers or sealed boxes.

Prevention through education and road signs is important, as well as:

- spatial and temporal organization of traffic;
- communication facilities covering the whole site;
- Regular maintenance of vehicles;
- Mandatory seatbelt reminders using signs but also by the guards stationed at various checkpoints;
- speed humps on critical access roads;
- staff awareness driving light and heavy vehicles for the purpose of decrease in speed;
- sanctioning users not respecting the instructions.

In an accident involving a chemical spill or fire, a small mobile unit for fire fighting and pollution control will be present on the site and will include neutralizing products tailored to the nature of risks (Calcium hypochlorite, absorbent mousses, etc).

A clinic will be built on the site and will be used for accidents resulting in personal injury. It will provide first aid emergencies or stabilize patients before evacuation by ambulance to Tengrela or Korhogo.

8.3.6.6 Aircraft crash

The risk of a plane crash is higher during landing and takeoff. In addition to the areas in the immediate vicinity of the airport, the risk of accidents is also higher in the space used for air traffic.

The mine site has an airstrip located about 1 km from the processing plant. There will be a relatively moderate level of air traffic in the vicinity of our study area.

The theoretical probability of plane crash on a property is the sum of the three individual probabilities of:

- plane crash during takeoff or landing phase, within the perimeter of an airport;
- crash of a civil aircraft in a circulating air corridor;
- crash of a military aircraft traveling in a restricted area.

The perimeter of the airport is defined as the area within more than 2 km from any point of take-off and landing runways. The airfield is located less than 2 km from the project site (around 1 km) the risk of plane crash could be considered a potential hazard and considered in accident scenarios. In addition, the feedback on aircraft crashes in Ivory Coast in general and in the Tengrela region in particular, includes proposed measures such as:

- maintenance and inspection of aircraft before takeoff;
- the establishment of a transport plan (flight schedule, safety rules, etc.);
- compliance with aviation regulations of the Côte d'Ivoire;
- maintenance of the airstrip;
- construction of the track in parallel to the facilities;
- emergency equipment;
- an emergency response plan.

8.3.6.7 Explosive Hazards

Storage and handling of explosives will be done in accordance with the law establishing the special conditions for manufacturing explosives in mobile installations in the opencast work in mines and quarries.

The type of explosive used will be sent and stored on site as inert compounds. Detonators are always in closed boxes and will be assembled with explosives before use only. The explosives are of low breaking capacity, thus limiting the projections of materials in use.

The site of the explosives store will be located far enough away from all project facilities and will be considered a high security area with fencing and constant supervision.

Handling explosives should only be done by authorized persons whose names, according to the regulations, will be communicated to the administration before getting permission. The procedures of use will also be part of the license application. They include all kinds of principles to limit risks.

These include the maximum charges used, the definition of the security perimeter, security period applied after detonation, the use of sirens, etc.

Risks related to the use of explosives will be limited to those who handle them because any other project infrastructure will be far enough away to not be in the risk zone.

8.3.6.8 Hazardous weather

Some natural climate events such as storms and flooding could lead to an emergency situation.

Floods can cause material damage to the various project facilities and overflow of basins containing cyanides. This kind of risk will be minimized by proper site design and water management infrastructure.

Some preventive measures are put in place just before the wet season:

- increase the capacity of the process water storage basin containing cyanides;
- Clean all gutters and drainage channels to prevent clogging by unwanted objects or soil;
- inspect the works of the dam for the presence of eroded areas, cracks, etc .;
- receive regular weather updates.

8.3.6.9 Social trouble

Perseus Mining is aware of the importance of maintaining a dialogue and good relations with local populations and authorities. Information meetings with different stakeholders will be organized regularly. This will apprehend potential problems before they become an important dimension, or uncontrollable.

Despite this proactive approach of the company, social unrest could occur for a variety of reasons. This includes workers or villagers engaging in subversive activities leading to violence that could cause injury to persons or destruction of property, and in some extreme cases, the taking of hostages.

To counter these extreme cases, an intervention program supported by the authorities of the Republic of Côte d'Ivoire will be implemented.

9.0 PUBLIC PARTICIPATION

Pursuant to Article 39 of the Law on the Environment Code, Article 77 of the Law on Mining Code and Performance Standards of the International Finance Corporation (IFC) on the environmental and social performance (April 2006) and the Equator Principles (March 2006), require that the proponent of a development project gives the opportunity to the public for participation in decision-making on improving the quality of environment.

Stakeholders and members of the public who desire to participate in the evaluation process are listed as the Interested and Affected Parties (PIA). The practice of disclosing information about the project and to meet with the PIA is known as the Public Participation Process (PPP).

9.1 PUBLIC PARTICIPATION PROCESS

Public participation during the environmental and social impact assessment of the Sissingue gold project aims to create an environment of informed participation and be constructive for all concerned or affected by the proposed development.

This is a bilateral reciprocal action, which does not seek to avoid conflicts but to facilitate a process in which people can express their opinions and where they feel included in decision making, leading to the identification of satisfactory results.

The public participation process has the following objectives:

- Identify all interested and affected parties by the project;
- Give accurate information about the project;
- Gather information that will contribute to environmental and technical investigations;
- Form partnerships and relationships that promote positive interactions between all parties;
- Deal with all possible conflicts;
- Take into account the concerns, problems and suggestions from the public and respond;
- Manage expectations of PIA;
- Comply with Ivorian and international requirements in terms of consultation.

9.1.1 Approach and Methodology

Perseus Mining Ivory Coast adopted a consultative approach in which the PIA are actively involved. The problems and concerns are taken into account during decision-making, so that favourable options can be explored.

As part of this consultative approach, the following steps have been put in place to ensure that this level of participation is reached (Figure 9.1).

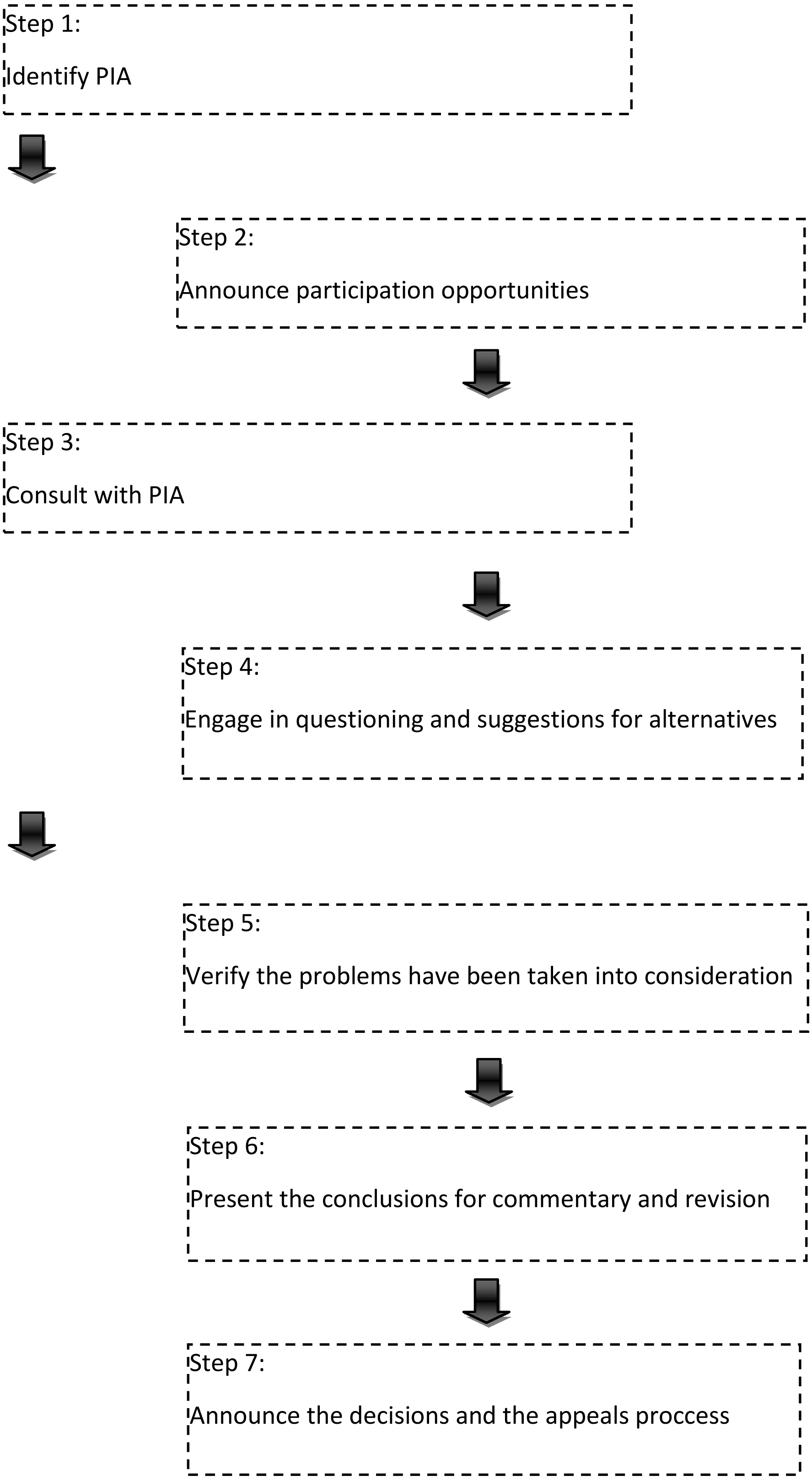


Figure 9.1 Process of public participation

9.1.2 Identification of Stakeholders

The stakeholders were divided into two groups: primary stakeholders and secondary stakeholders (**Table 9.1**)

Table 9.1 Primary and secondary stakeholders

Primary Stakeholders	Secondary Stakeholders
Residents directly affected and land users (the chief and elders, youth, women and vulnerable groups).	National and international organizations in the country.
Supervisors, counselors, Prefect, Sub-Prefect and tribal authorities governing the project area directly affected covering local and regional levels.	Other groups including environmental associations, professional agricultural associations and business groups.
Ministry of the Environment and Sustainable Development; Ministry of Mines and Industry Ministry of Agriculture Ministry of Wildlife and Fisheries; Ministry of Economic Infrastructure;	Local, regional and national agencies operating in the sector.

From these identified groups, a PIA database was established for all known stakeholders at national, regional and local level.

9.1.2.1 Affected Parties

The parties directly affected in the primary stakeholder group were further divided into two categories, namely:

- communities and the town directly affected by the proposed mine and its infrastructure. This is the Sissingue village and surrounding hamlets.
- communities and villages on the Tengrela- Sissingue axis that may be affected due to their proximity to the future mine and infrastructure (Tialaka, Mbasso and Kanakono). The potential upgrading of the road system between Korhogo and Sissingue could also affect some villages.

In order to involve all stakeholders in the public participation process, all the villages of the entire exploration permits were consulted (see initial report).

These stakeholder groups were identified in the field and dialogues were held between CECAF International, the leaders and the people of the villages concerned in the presence of Perseus Mining Ivory Coast.

9.1.2.2 Authorities

The Government of Côte d'Ivoire is divided into four main levels of government:

- Regional authorities;
- the departmental authorities;
- district authorities;
- tribal authorities.

The following relevant authorities have been identified at the departmental level:

- Departmental Directorate of Health;
- Departmental Direction of Agriculture and Fisheries;
- Departmental Direction of Education;
- Departmental Direction of Mines;
- Departmental Direction of Economic Infrastructure.

The following relevant authorities have been identified at a national level:

- The Ministry of the Environment and Sustainable Development;
- The Ministry of Agriculture;
- The Department of Animal and Fishery Resources
- The Ministry of Economic Infrastructure;
- The Ministry of Higher Education and Scientific Research;
- The Ministry of Mines and Industry;
- The Department of State, Ministry of Interior and Security;
- The Ministry of Education;
- The Ministry of Communication;
- The Ministry of Family, Women and Children.

In the field mission CECAF International and the writing of this report, the majority of the officials of the local administration had not worked in the north since the beginning of the crisis. According to the Prefect of Tengrela, the redeployment of the administration will be phased in the department. However, very few officials of other sectors have been deployed. Information sharing meetings with national, regional and local authorities took place. Since this process of administrative transmission continues to evolve, CECAF International continued its public consultation mission before and after the democratic elections of 30 October 2010.

9.1.2.3 Interested Groups

This stakeholder group represents groups with business or civil project interests. These groups may include NGOs and other important regions in the surrounding area. Within this group are also a small number of international organizations, with representation in the Ivory Coast, who are involved in sustainable development, environment and health, as well as academic institutions and research organizations.

9.1.3 Notification of Stakeholders

The methods of notifying participants varies according to the stakeholder group concerned, the nature of the area and the communication mechanisms available. Often a multitude of media is used to ensure the broadest scope of this notification.

The approach is direct communication between the PIA, CECAF International and Perseus Mining.

The communication used was mail, telephone and fax wherever possible to contact the local authorities, the public and other stakeholders.

9.1.4 Information Sharing Meetings

The information-sharing meetings between the authorities, the public and the community took place in January, February and May 2011. The purpose of these meetings was to inform stakeholders of the Sissingue gold project and consolidate all information issued concerns or suggestions.

The **Table 9.2** below shows the information sharing meetings program.

Table 9.2 Program of information sharing meetings

Consultation Dates	**Localities**
Saturday 29 January 2011	Sissingué and Gbini
Sunday 30 January 2011	Kanakono and Zanikan
Monday 31 January 2011	Pourou and Ziékoundougou
Tuesday 1 February 2011	Kotou and Katara
Wednesday 2 February 2011	Danzourou and Tiongoly
Thursday 3 February 2011	Tialaka
Friday 4 February 2011	M'Basso
Thursday 28 and Friday 29 May 2011	Papara
Monday 30 and Tuesday 31 May 2011	Doubasso
Tuesday 31 May and Wednesday 1 June 2011	Basso

9.2 RESULTS OF THE MEETINGS

The issues discussed in this section were taken from information sharing meetings, which the community and affected parties participated. The PIA involved in the project were able to identify a number of issues that can be associated with the operationalization of a new gold mine in the region.

The main concerns are the following:

- The high cost of living in the village;
- fear of moral depravity due to the influx of immigrants and non-indigenous populations;
- the development of crime (theft, drugs);
- total loss of land for agriculture after mining;
- risks related to potential chemical spills in rivers and soils that could cause impacts on the state of the village environment;
- risks related to diseases from the influx of people seeking employment;
- abandonment of farming by young people in favor of working at the mine;
- loss of regular financial gains from land rent;
- the low level of compensation;
- destruction of perennial crops;
- destruction of sacred sites because of mining activity;
- the weakening of the family structure and divorces, possibly related to the influx of people;
- the problems of coexistence between indigenous populations and diverse backgrounds;
- desecration of sacred sites of the town and the region;
- the loss of ancestral land rights;
- road safety because of the influx of traffic;
- retraining issues of youth in the closure of the mine;
- loss of cultural identity.

9.3 RESOLUTION OF IDENTIFIED PROBLEMS

An Advisory Committee will be established and serve as a community liaison and affected communities will participate in ongoing communication with Perseus Mining before and during the project.

The problems identified and listed abover have all been included in the Preliminary Environmental Management Plan.

9.4 IMAGES OF PUBLIC PARTICIPATION

9.4.1 Meeting with village chiefs and Kanakono notables




9.4.2 Meeting with landowners

9.4.3 Meeting with the people of Sissingué




10.0 REFERENCES

Institut National de la statistique - Zanou B. : Recensement général de la population et de l'habitat de 1998, volume IV : analyse des résultats, Tome 2, migrations, Abidjan, 2001.

Institut National de la statistique - Bureau Technique Permanent du Recensement : Recensement général de la population et de l'habitat de 1998, volume III : données sociodémographiques et économiques des localités, Tome I : résultats définitifs par localité, Région Bas Sassandra, Abidjan, 2002.

ANONYME 2002, Plan de déplacement et de réinstallation des personnes affectées par le projet d'extension du port à Yopougon, TERRABO. Rapport provisoire 3.

Banque Africaine de Développement / Fond Africain de Développement (1995), *Directives d'évaluation de l'impact des projets miniers sur l'environnement*, Abidjan, Côte d'Ivoire, juin 1995, 76p.

BNETD 2002, Projet d'étude technique pour l'aménagement de la desserte des sites d'extension du Port d'Abidjan à Yopougon Santé et à l'Ile Boulay. Etude d'impact sur l'environnement.

BNETD 2001, Projet d'extension du Port d'Abidjan à Yopougon. Etude socio-économique. Rapport provisoire.

BOUDON (R), 1970, Les méthodes en sociologie Paris P.U.F. Armand Colin.

CAPLOW (T), 1970, L'enquête sociologique, Paris, Armand Colin.

De BRUYNE (P) et Ai, 1974, Dynamisme de la recherche en sciences sociales, Paris, P.U.F.

Durkheim (E), 1983.Les règles de la méthode sociologique, Paris, P.U.F.

GOH D. 2005, Les approches participatives dans la gestion des aires protégées en Côte d'Ivoire : l'expérience du projet Autonome pour la Conservation du Parc National de Taï, *Thèse unique de doctorat. Université d'Abobo-Adjamé*, Abidjan, 2005.

GOH (D), 2007, Etude de faisabilité technico-économique du projet d'aménagement de 900 hectares au Nord- Ouest de la Côte d'Ivoire : Aspects environnementaux. ICI Infrastructures Abidjan.

GOH (D), 2007, Etude d'impact environnemental du Projet Minier d'Angovia ; volet socioéconomique. Rapport provisoire

GOH (D), 2007, Etude d'évaluation environnementale et sociale des complexes sucriers ivoiriens : état de référence et grands enjeux de gestion durable. Aspects socioéconomiques. Phase 2. Rapport provisoire

GOH (D), 2008, Etude d'évaluation environnementale et sociale des complexes sucriers ivoiriens : état de référence et grands enjeux de gestion durable. Aspects socioéconomiques. Phase 1. Rapport provisoire

GOH (D), 2008, Etude d'impact environnemental du Projet Minier d'Agbaou ; Réalisation du plan de relocalisation des personnes de la zone du projet. Rapport provisoire

GOH (D), 2008, Etude d'impact environnemental du Projet Minier d'Agbaou ; volet socioéconomique. Rapport provisoire

GOH (D), 2009, Etude socio-environnementale des relations entre les populations riveraines et le Parc National de Taï. Rapport provisoire

GOH (D), 2009, Etude d'impact environnemental du Projet Minier de Bondoukou ; volet socioéconomique. Rapport provisoire.

GOH (D), 2010, Etude de faisabilité socioéconomique du projet de relance de la conservation du Parc National de la Comoé. Rapport définitif.

GOH (D), 2010, Etude de faisabilité environnementale de trois (03) ouvrages d'art à Bassawa (sur la Comoé), Kouibli (sur le Sassandra) et Kani (sur la Marahoué). Rapport définitif.

ANONYME. 1981. Guide de terrain des Gastéropodes d'eau douce africains. I- Afrique occidentale. Danish bilharziasis laboratory, 31 p.

BROWN D.S. 1980. Freshwater snails of Africa and their medical importance. Taylor and Francis Ltd, London, 487 p.

BROWN D.S. 1994. Freshwater snails of Africa and their medical importance. Taylor and Francis Ltd, London, 608 p.

DAGET J. 1954. Les poissons du Niger supérieur. *Mem. IFAN (Inst.Fr.Afr.Noire),* 36: 382 p

DEJOUX C. 1983. Utilisation du téméphos en campagne de lutte contre *Simulium damnosum* en Afrique de l'ouest. Impact des premiers cycles de traitement sur le milieu aquatique. *Rev. Hydrobiol. Pop.,* 16 (2): 165- 179.

DEJOUX C., ELOUARD J.M., FORGE P. & MASLIN J.L. 1981. Catalogue iconographique des insectes aquatiques de Côte d'Ivoire. Rapport ORSTOM, 42, 178 p.

DURAND J–R. & LEVEQUE C. (eds) 1980. Flore et faune aquatiques de l'Afrique sahelo-soudanienne. Tome

1. ORSTOM, Paris. pp 1-390.

DURAND J.–R. & LEVEQUE C. (eds) 1981. Flore et faune aquatiques de l'Afrique sahelo-soudanienne. Tome 2. ORSTOM, Paris. pp 391-873.

HALLE B. & BRUZON B. 2006. Profil environnemental de la Côte d'Ivoire. Rapport final Commission Européenne, 128 p.

IRD. 2010. La pêche dans le Delta Central du Niger. Les dossiers thématiques de l'IRD. Site web : http://www.mpl.ird.fr/suds-en-ligne/fr/eau/delta/delta3.htm#suds

LEVEQUE C. & PAUGY D. 2006. Distribution géographique et affinités. *In* : Les poissons des eaux continentales africaines ; diversité écologie, utilisation par l'homme (C. Lévêque & D. Paugy, eds), IRD, pp : 7- 10.

MINISTERE DE L'ENVIRONNEMENT ET DE LA FORET. 1999. Diversité Biologique de la Côte d'Ivoire. (J.B.L.F. Avit, P.L. Pedia et Y. Sankaré, Eds), http://bchbd.naturalsciences.be/civoire/contribution

/monographie/monographie.pdf. 273p.

MINISTERE DU LOGEMENT DU CADRE DE VIE ET DE L'ENVIRONNEMENT, 1997. Côte d'Ivoire - Profil environnemental de la zone côtière. http://www.globaloceans.org/icm/profiles/cote/cote.pdf: 59 p.

NEEDHAM R. 1962. A guide to study of freshwater biology. San-Francisco Holden Day, Inc, 105 p.

OUATTARA A. 2000. Premières données systématiques et écologiques du phytoplancton du lac d'Ayamé (Côte d'Ivoire). Thèse de Doctorat. Katholieke Universiteit Leuven, Belgique, 207 p.

OUATTARA A., PODOOR N. & GOURENE G. 2001. Études préliminaires de la distribution spatio-temporelle du phytoplancton dans un système fluvio-lacustre africain (Bassin Bia ; Côte d'lvoire). *Hydroécol. Appl.*, 13: 113-132

OUATTARA A., PODOOR N., TEUGELS G.G. & GOURENE G. 2000. Les micro-algues de deux cours d'eau (Bia et Agnébi) de Côte d'Ivoire. *Systematics and Geography of plant*, 70 (2): 46-70.

PAUGY D., LEVEQUE C. & TEUGELS G.G. 2003 a. Poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Tome 1 (Paugy D., Lévêque C. et Teugels G.G., eds), IRD, Paris, 457p.

PAUGY D., LEVEQUE C. & TEUGELS G.G. 2003 b. Poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Tome 2 (Paugy D., Lévêque C. & Teugels G.G., eds), IRD, Paris, 815p.

PNUE. 2002. Manuel de formation sur l'étude d'impact environnemental. Barry Sadler et Mary McCabe (eds). 630p.

POURRIOT R. 1980. Les Rotifères. *In*: Flore et faune aquatiques de l'Afrique Sahelo-Soudanienne Tome 1 (Durand J. -R. & Lévêque C., eds). ORSTOM, Paris. pp 333-356.

REY J. & SAINT-JEAN L. 1980. Branchiopodes (Cladocères). *In*: Flore et faune aquatiques de l'Afrique Sahelo-Soudanienne Tome 1 (Durand J. -R. & Lévêque C., eds). ORSTOM, Paris. pp 307-332.

REY J. 1986. Contribution à l'étude du zooplancton d'altitude et la taxinomie des Cladocères. Thèse de Doctorat. Université Paul Sabatier de Toulouse, France, 443 p.

RUTTNER A.K. 1974. Plankton Rotifers: Biology and taxonomy. *In*: Die Binnengewässer. Vol. XXVI/1. supplement. Stuttgart, 146 p.

SALE A. 2007. Étude pour la mise en place d'un réseau de recherche et développement a l'échelle du bassin du Niger. Rapport national provisoire*,* Autorité du bassin du Niger, Côte d'Ivoire, 105p.

TEUGELS G.G., LEVEQUE C., PAUGY D. & TRAORE K. 1988. État des connaissances sur la faune ichtyologique des bassins côtiers de Côte d'Ivoire et de l'Ouest du Ghana. *Revue d'Hydrobiologie tropicale,* 21 (3): 221-237.

UNDP, 2003. Local Business for Global Biodiversity Conservation, UNDP, 77p.

UNEP-FAO. 1981. Tropical Forest Assessment Project. Forest resources of tropical Africa. Part II. Country Briefs. UNEP-FAO, Rome, 739 p.

UNEP-WCMC, 2007. Biodiversity and Poverty Reduction: The importance of biodiversity for ecosystem services. Huntingdon Rd, Cambridge, CB3 0DL, 38p.

YAMEOGO L., LEVÊQUE C., TRAORE K. & FAIRHURST C.P. 1988. Dix ans de surveillance de la faune aquatique des rivières d'Afrique de l'ouest traitées contre les simulies (Diptera: Simuliidae), agents vecteurs de l'onchocercose humaine. *Rev. Eco/. syst.,* 11 (5): 287-298.

YAO S.S. 2006. Etude de la diversité biologique et de l'écologie alimentaire de l'ichtyofaune d'un hydrosystème ouest africain : cas du bassin de la Comoé (Côte d'Ivoire). Thèse de doctorat, Université de Cocody-Abidjan, Côte d'Ivoire, 280p.

YAO S.S., KOUAMELAN E.P., KONE T., N'DOUBA V., GOORE Bi G., OLLEVIER F. & THYS Van Den AUDENAERDE D.F.E. 2005. Fish communities along environmental gradients within the Comoé River basin, Côte d'Ivoire. *African Journal of Aquatic Science*, 30 (2): 185–194.

ADJANOHOUN, E. et GUILLAUMET, J.L. (1971) La végétation. In J.M. Avenard et al. (Eds) Le milieu naturel de la Côte d'Ivoire. Mémoires ORSTOM, n° 50 p. 157-262.

VICKOS J.B. (1991) Télédétection des feux de végétation en Afrique Intertropicale et estimation des émissions des constituants ayant un intérêt atmosphérique. Thèse de Doctorat, Université Paul Sabatier, Toulouse III, France, 142 p.

N'GUESSAN K. E., H. DIBI N'DA, M.-F. BELLAN et F. BLASCO 2006 - Pression anthropique sur une Réserve Forestière en Côte D'ivoire : Apport de la Télédétection. Télédétection, vol. 5, n° 4, pp. 307-323

ADJANOHOUN E., 1964. Végétation des savanes et des rochers découverts en Côte-d'Ivoire. Mém. ORSTOM, 7:178 p.

AKE ASSI, L., 1998. Impact de l'exploitation forestière et du développement agricole sur la conservation de la biodiversité biologique en Côte d'Ivoire. Le flamboyant **N° 46 Déc.**: 20-21.

ANONYME, 2000. Red list of threathened species. (IUCN) Website: http: // www.redlist.org.

CESAR J. & MENAUT, J, C., 1974. Peuplement végétal *In* : Analyse d'un écosystème tropical humide : la savane de Lamto (Côte-d'Ivoire), N° spécial (2), Bull. Cherch. Lamto, 161 p.

CESAR J., 1971. Etude quantitative de la strate herbacée de la savane de Lamto (Average Côte-d'Ivoire). Thèse de doctorat 3e cycle, Paris, France, 252 p.

DEVINEAU J., 1975. Etude quantitative des forêts galeries de Lamto (Average Côte-d'Ivoire). Thèse de doctorat 3e cycle, Université de Paris VI, Paris, France, 190 p.

FAURIE C., FERRA C. & MEDORI P. D. J., 1998. Ecologie : approche scientifique et pratique. Technique et Documentation, 339 p.

GAUTIER L., 1990. Contact forêt-savane en Côte d'Ivoire Centrale ; évolution du recouvrement ligneux des savanes de la réserve de Lamto (Sud du V-Baoulé), Candollea, 45 : 628-629.

HOLMGREN, M., POORTER, L., SIEGEL, A., BONGERS, F., BUITELAAR, M., CHATELAIN, C., GAUTHIER, L., HAWTHORNE, W.D., HELMINK, A.T.F., JONGKIND, C.C.H., OS-BREIJER, H.J., WEIRENGA, J.J. , & VAN ZOEST, A.R.
2004. Ecological profiles of rare and endemic species. *In* POORTER, L., BONGRES, F., KOUAMÉ, N. F. & HAWTHORNE, W. D. [eds.], Biodiversity of West African forests, an Ecological Atlas of Woody plant Species, CABI Publiching, Cambridge, 101-389.

IUCN 2006. Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 13 August 2006.

JONGKIND, C.C.H. , 2004. Checklist of Upper guinnea forest species. *In* POORTER, L., BONGRES, F., KOUAMÉ, N.

F. & HAWTHORNE, W. D. [eds.], Biodiversity of West African forests, an Ecological Atlas of Woody plant Species, CABI Publiching, Cambridge, 447-447.

MENAUT J. C. & CESAR J., 1979. Structure and primary productivity of Lamto savannas (Ivory Coast). Ecology, 60 : 1197-1210.

MENAUT J. C., 1971. Etude de quelques peuplements ligneux d'une savane guinéenne de Côte-d'Ivoire. Thèse de doctorat 3e cycle, Paris, France, 141 p.

MYERS N., MITTERMEIER R. A., MITTERMEIER, C. G., DA FONSECA, G. A. B. et KENT, J., 2000 - Biodiversity

hotspots for conservation priorities. Nature, 403 : 853-858.

POLLET A., 1972. Contribution à l'étude du peuplement d'insectes d'une lisière entre forêt-galerie et savane éburnéenne. I- Données générales sur les phénomènes. Ann. Univ. Abj., E, **5** (1) : 395-473.

ROLAND J. C. & HEYDACKER F., 1967. Aspect de la végétation de la savane de Lamto (Côte-d'Ivoire). Rev. Gén. Bot., 70 : 605-620.

ALONSO, L.E., LAUGINIE, F. et RONDEAU G., 2005. Une évaluation biologique de deux forêts classées du sud-ouest de la Côte d'Ivoire. Bulletin RAP d'Evaluation Rapide 34. *Conservation International*. Washington, D.C, 168p.

ANONYME, 2004. Stratégie de gestion durable des éléphants en Côte d'Ivoire. Ministère des Eaux et Forêts, Abidjan, 99p.

BIRDLIFE INTERNATIONAL, 2000. Threatened Birds of the World. Cambridge, U.K.: BirdLife International & Barcelona, Spain: Lynx Edicions. BirdLife Conservation Series No. 7.

BIRDLIFE INTERNATIONAL, 2009. Threatened Birds of the Worl*d*. Cambridge, U.K.: BirdLife International & Barcelona, Spain: Lynx Edicions. BirdLife Conservation Series No. 7.

BORROW (N) & DEMEY (R), 2001. Birds of Western Afric*a*. Christopher Helm, London, 832p.

BURNHAM, K.P., ANDERSON, D.R., LAAKE, J.L. (1980). Estimation of density from line transect sampling of biological populations. *Wildl. Monog.* 72, 205 p.

CHAPPUIS, C., 2000. Les oiseaux de l'ouest africain. Sound supplement to *Alauda.* 15 CD-ROM. Paris : Société d'études ornithologiques.

DAVID (N) & GOSSELIN (M), 2002a. Gender agreement of avian species names. *Bull. Br. Ornithol. Cl*. 122: 14–49.

DAVID, (N) & GOSSELIN (M), 2002b. The grammatical gender of avian genera. *Bull. Br. Ornithol. Cl*. 122: 257–282.

FGU-KRONBERG, (1979). Etat actuel des parcs nationaux de la Comoé et de Taï, ainsi que de la réserve d'Azagny et proposition visant à leur développement aux fins de promotion du tourisme. (Tome 3, Parc National de Taï. FGU Kronberg consulting and engineering). 155 p.

FISHPOOL, L.D.C., 2001. Côte d'Ivoire. In *L.D.C. Fishpool et M.I. Evans eds.* Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservatio*n.* Newbury*: Pisces Publications & Cambridge, UK: BirdLife International.* pp. 219-232

GUILLAUMET, J. L. & ADJANOHOUN, E. (1971). La végétation de la Côte d'Ivoire. *In :* Le milieu naturel de la Côte d'Ivoire. *Mém. ORSTOM,* Paris ; 50 :161-263.

HALLE, B. et BRUZON, V., 2006. Profil Environnemental de la Cote d'Ivoire. Rapport final, AGRIFOR Consult, Belgique, 128p.

ICBP. 1992. Putting biodiversity on the map: priority areas for global conservation. International Council for Bird Preservation. Cambridge, UK.

KINGDON, J. 1997. The field guide to African Mammals (Academic, San Diego).

KINGDON, J. 2004. Guide des mammifères d'Afrique.The field guide to African Mammals (Academic, San Diego).

POILECOT P., BONFOU K., DOSSO H., LAUGINIE F., N'DRI K., NICOLE M. et SANGARE Y., 1991. Un écosystème de savane soudanienne : le Parc National de la Comoé (Côte d'Ivoire). Note technique 2 n°IVC/87/007 , 346 p.

POLLOCK, K.H. (1978). A family of density estimators Line-Transect Sampling. Biometrics 34, 475-478.

SCHWARZ C.J. and ARNASON A.N., 1996. A general methodology for the analysis of capturerecapture experiments in open populations. *Biometrics* 52: 860-873.

SEBER G. A. F. 1986. A review of estimating animal abundance. *Biometrics* 42: 267-292.

STATTERSFIELD (A.J), CROSBY (M.J), LONG (A.J) & WEGE (D.C), 1998. Endemic Bird Areas of the World: Priorities for Biodiversity Conservation. BirdLife International. Cambridge, UK. Series No 7, 846 p.

SUTHERLAND W.J. 1996. Ecological census techniques: A handbook. Cambridge University Press, Cambridge. 336 p.

UICN. (2003). Lignes Directrices pour l'Application, au Niveau Régional, des Critères de l'UICN pour la Liste Rouge. Commission de la sauvegarde des espèces de l'UICN. UICN, Gland, Suisse et Cambridge, Royaume- Uni. ii + 26 p.

WILLIAMS B.K., NICHOLS J.D. and CONROY M.J., 2002. Analysis and management of animal populations. Academic Press, San Diego, California. 817 p.

CIRAD, GRET (2002) - Mémento de l'Agronome

CAMBRONY, H.R., 1989. Le caféier, Collection Le technicien d'agriculture tropicale, Maisonneuve et Larose, CTA.

WILLSON, K.C., 1999. Coffee, Cocoa and Tea, Collection Crop Production Science in Horticulture, Cabi Publishing.

Guédé Y., 2003. « L'Afrique de l'Ouest, berceau de la métallurgie ancienne du fer » ; (pour le compte du Patrimoine Culturel de Côte d'Ivoire) en collaboration avec le Musée Royal de l'Afrique Centrale et avec l'aide de la Coopération Belge au Développement. Salle des sciences. Tervuren.

Guédé Y., 1987. « Les collections archéologiques (néolithiques et paléolithiques) du musée national de Côte d'Ivoire », An. Univ. Abidjan, tome XV.

Guédé Y., 2002. « Recherches palééolithiques dans le Haut Sassandra (Avril 1984-Août 1985) : résultats préliminaires in Rév-Hist. Art et Archéol. Godo Godo n°14, EDUCI, pp 7-27.

Lioubine V.P, Guédé Y., « Le paléolithique de la Côte d'Ivoire » (Afrique de l'Ouest). (paru en Russe). Ed. Vostokovediédignia, Rossiiskaïa Akademia Nauk, Sankt-Peterburg.

Lioubine V-P, Guédé Y., 1999. « Isslédovania paleolita V Zapadnoï Afriki (Respublika Kot d'Ivoir). (« Recherches paléolitiques en Afrique de l'Ouest ») ; paru en Russe in Archéologuisheskii. Sankt- Peterbourg. N°6. Rossiiskaïa Akademia Nauk. Pp 19-40

La Direction du Patrimoine de Côte d'Ivoire ; « La métallurgie du fer en Côte d'Ivoire : les matières premières ». en collaboration avec le Musée Royal de l'Afrique Centrale et avec l'aide de la Coopération Belge au Développement. Salles des Sciences. Tervuren, 2003.

Plan National de Développement Sanitaire 2008-2012, Ministère de la Santé et de l'Hygiène Publique, République de Côte d'Ivoire, Janvier 2008.

Rapport annuel d'activités 2009 du District Sanitaire de Tengrela.

Rapport sur la situation sanitaire des années 1999 et 2000, Ministère délégué auprès du Ministre de la solidarité chargé de la santé, République de Côte d'Ivoire, Abidjan, Novembre 2002, DIPE.

Manuel des directives du PMA des ESPC, Ministère de la Santé Publique, République de Côte d'Ivoire, 2000, NEI.

Manuel des directives du PMA de l'hôpital de référence des districts de santé, Ministère de la Santé Publique, 2000, République de Côte d'Ivoire, Ministère de la Santé et de l'Hygiène Publique, République de Côte d'Ivoire, PUCI, Décembre 2006.

Code de l'environnement et textes de références en matière de protection de l'environnement en Côte d'Ivoire 2008, Ministère de l'Environnement, des Eaux et Forêts, ANDE, République de Côte d'Ivoire.

REPUBLIQUE DE CÔTE D'IVOIRE
– - Travail

MINISTÈRE DE L'ENVIRONNEMENT, DES EAUX ET FORETS

Agence Nationale De l'Environnement (ANDE)

TERMES DE REFERENCE

DE L'ETUDE D'IMPACT ENVIRONNEMENTAL

Projet Aurifère de Sissingué dans le Département de TENGRELA

AVRIL 2009

TDR d'EIE n°8 -0604-09

11.0 TERMS OF REFERENCE

ANDE	**:**	National Environment Agency (Agence Nationale De l'Environnement)
BEE		Office of Environmental Studies (Bureau d'Etudes Environnementales agréé par le Ministère de l'Environnement, des Eaux et Forêts)
CIAPOL	**:**	Ivorian Antipollution Centre (Centre Ivoirien Antipollution)
DGE	**:**	General Director of the Environment (Direction Générale de l'Environnement)
EIE	**:**	Environmental Impact Studies (Etudes d'Impact Environnemental)
MINEEF	**:**	Minitster for the Environment (Ministère de l'Environnement, des Eaux et Forêts)
PDR	**:**	Displacement Plan (Plan de Déplacement et de Réinstallation)
PGE	**:**	Environmental Management Plan (Plan de Gestion Environnementale)
PNAE	**:**	National Action Plan for the Environemnt (Plan National d'Action pour l'Environnement)
POI	**:**	Internal Operations Plan (Plan d'Opération Interne)
OCG	**:**	Occidental Gold
TDR	**:**	Terms of Reference (Termes De Référence)

INTRODUCTION

To deal with environmental problems, Côte d'Ivoire has, since 1992, a National Action Plan for the Environment. This constitutes policy framework to better understand the complexity of environmental issues. The implementation of this plan requires the prior definition of an institutional, legislative and legal framework to register environmental actions in Côte d'Ivoire.

At the legislative level, the Law of the Environment Code was passed, while at the regulatory level, Decree No. 96-894 of 8 November 1996 created rules and procedures for studies on the environmental impact of development projects. Institutionally, the National Agency for the Environment (ANDE) was created by Decree No. 97-393 of July 9, 1997. One of their tasks is to ensure the inclusion of environmental considerations into all project and program development.

The general principles on which the Ivorian environmental policy are:

- The precautionary principle,
- The principle of substitution,
- The preservation of biodiversity,
- The non-degradation of natural resources,
- Information and public participation and finally,
- The promotion of cooperation.

Despite the economic, financial and social opportunities offered by the project, there will be negative consequences on the environment.

Therefore, the Environmental Impact Assessment is an essential approach to identify the effects of such activity on the physical as well as human environment and propose solutions. Indeed, this environmental management tool not only helps to design a more environmentally conscious project without putting at stake its technical and economic feasibility, but also helps identify critical elements that support the choices and decisions.

The Environmental Impact Assessments are the responsibility of the National Agency for the Environment (ANDE) including the development of the EIS Terms of Reference in consultation with the technical supervisory authority, the owner and possibly the public as stipulated in paragraph 2 of Article 11 of the Decree of 8 November 1996.

CONTEXT OF THE STUDY

The Ivorian Government has granted the Exploration Permit PR 105 to the OCCIDENTAL GOLD in the Sub prefecture of Tengrela. This permit covers an area of 443 km2. Following an extensive exploration program, OCCIDENTAL GOLD identified a gold deposit near the village of Sissingue in the Department Tengrela, Ivory Coast.

The project is currently in the feasibility phase, including the development of mineral resource estimates and the evaluation of the economic viability of mining the deposit. A component of this feasibility study is evaluating the impact on the environment through the implementation of an Environmental Impact Assessment (EIA).

This document, Terms Of Reference (TOR) is a reference guide for the operation of a gold mine in the Tengrela Sub Prefecture.

These Terms of Reference (TOR) aim firstly to bring the project proponent (OCCIDENTAL GOLD) to develop an EIA report complying with the legislation, and also to define a methodological framework including the major challenges of the project.

These Terms of Reference (TOR) demonstrate the principles of a clear and consistent approach to provide the relevant information required for the environmental assessment of the project.

The TOR describe the actions needed to deal with all the technical, legal, procedural issues through development of an EIA report. The TOR further describes the scope of work to be done by the firm or chosen by the owner.

In addition, TOR help decision making by government authorities including the Ministry of Environment, Water and Forests and the Ministry of Mines and Energy.

The TOR were developed on the basis of the information contained in the technical file of the project and the specifics of the project site environment Village level Sissingue.

OBJECTIVES OF THE STUDY

According to TOR, the Office of Environmental Studies approved by the Ministry of Environment, Water and Forestry, OCCIDENTAL GOLD will conduct the Environmental Impact Assessment (EIA). This study, is intended to identify sensitive elements existing in the project environment, identify parts of the project may have effects on the environment, to assess the importance of these impacts, and recommend mitigation measures and actions where necessary.

Specifically, and in accordance with Decree No. 96-894 of 8 November 1996 regarding rules and procedures applicable to studies on the environmental impact of development projects, the study will:

- briefly describe the whole project including discharges and pollution and explain the context of its realization (and because environmental and technical rationale for the choice of the project);
- present and describe all components of the initial state of the natural and human environments of the project site likely to be affected;
- demonstrate how the project fits into the environment, presenting a detailed analysis of the potential impacts (positive and negative) and defining measures to address adverse impacts on environmental quality and maximize those likely improve;
- evelop a methodology for assessing the significance of impacts qualitatively and / or quantitatively, using, if necessary, the tool for economic valuation of environmental damage;
- provide for monitoring and follow-up programs (Environmental Management Plan) to ensure compliance with legal and environmental requirements;

TASKS OF THE ENVIRONMENTAL STUDIES OFFICE

Given the context and the study objectives, the tasks of Environmental Studies Office for the EIA will focus on the following points:

III-1- PRESENTATION OF INSTITUTIONAL, LEGISLATIVE AND REGULATORY FRAMEWORK

This part of the study aims to present the institutional and regulatory framework that underpins this type of project. The following aspects will be presented.

III-2– INSTITUTIONAL Framework

The institutional framework concerns national, public, private and other types of intervention at all stages of implementation of the project. These interventions will be in the form of monitoring and verification of environmental compliance, assistance and support during the implementation of measures to eliminate, reduce or offset the adverse consequences of the project on the environment.

The specific activities of various ministries, the private sector and local government should also be described succinctly, emphasizing their interest in the implementation of this project.

In the case of the Ministry of Environment, Water and Forestry (MINEEF), the structures directly involved in the implementation of this project will be taken into account, in particular, the Directorate General Environment (DGE), the National Agency for the Environment (ANDE), the Ivorian Anti-Pollution Centre (CIAPOL) and the General Directorate of Forestry and Water Resources Management.

The services and directorates of the Ministry of Mines and Energy, including the Interministerial Mining Commission, the Directorate of Mines and the Directorate of Geology will be considered in the process, as well as those of the Ministries of Agriculture, Building and Urban Development.

There will be consultations with all ministries to collect information useful for the effective and efficient implementation of this project, relative to its environmental component. Emphasis will be placed on decentralized Tengrela structures that are involved in the project.

This list is far from exhaustive. This should be completed by the owner and the Environmental Studies Office that carries out the EIA.

III.1.2– LEGISLATIVE AND REGULATORY FRAMEWORK

The Environmental Studies Office will provide a summary of the Ivorian regulations on the quality of the environment, health and safety, the protection of sensitive areas and the land use control measures of the works. It will also procure laws and regulations in the field of waste management.

Similarly, the Environmental Studies Office will make a description of regulations, norms and standards with regard to its environmental policy to be taken into account in the field of occupational health and safety to ensure environmental quality at both a national, regional and local level.

The Environmental Studies Office must refer to the text below by presenting all items that relate to the project activities:

- Environment Code;
- Mining Code;
- Water Code;
- Labour Code;
- Act for Protection of Public Health and Environment against the effects of toxic industrial and nuclear waste and harmful toxic substances;
- Act on Social Security;
- Act to transfer and distribution of powers from the state to local governments;
- Decree on the hygiene committee, safety and working conditions;
- Decree establishing the rules and procedures applicable to studies related to the environmental impact of development projects;
- Decree on installations classified for environmental protection.
- Decree on the control of the Technical Advisory Committee for the study of issues of hygiene and safety of workers;
- Decree establishing the rules for compensation for destruction of crops;
- Decree on Crown land and procedures;
- Decree on the customary land rights for public interest;
- Decree on Environmental Audit;
- Order determining the scale of compensation for crops.
- Application Order of the Decree on Environmental Impact Assessments;
- Application Order of the Decree on Environmental Audit;

This list is far from exhaustive. It must be complemented by other various ministries and administrative bodies involved in the project.

III.2 - DESCRIPTION OF THE PROJET

The Consultant will carry out the project description. This project description will include all the relevant details for the identification of sources of impact and their effects on the relevant environmental components.

In this regard, the items will describe the components, technical characteristics, operations and activities during the different phases of the project, including related activities involved.

This description will consider the following :

III.2.1 - CONTEXT OF THE PROJECT

This section of the study aims to identify the environmental, social, economic and technical elements of the project at the local and regional and internationael level.

The description of the project context includes a short presentation of the initiator, and a presentation of the project context in order to situate it in its environment.

- Intorduction of the contractor

The Environmental Studies Office will introduce OCCIDENTAL GOLD (social reasons, the location of its headquarters) and, if applicable, its sub-contractor on the project. This presentation includes background information on its history in relation to the proposed project, the industry in which the project is located.

- Introduction of the project context

This presentation will cover the following points:

- The history of the project, problems to solve, unmet needs, market opportunities in the project business sector;
- Project objectives;
- Favourable or unfavourable aspects of the project in relation to these problems or needs and market conditions (advantages and disadvantages);
- Interests and major concerns of various stakeholders;
- The technical and economic requirements of the project for its implementation and operation, particularly in terms of importance and implementation schedule;
- Government policies with regard to the project activity sector.

- Analysis of alternatives

The analysis of alternatives or options of the project is a very important step in the environmental assessment process. This is to show why the project was selected. This will show that the option chosen is in total agreement with environmental requirements. The study should make clear the objectives and criteria for selection of OCCIDENTAL GOLD.

III.2.2 - GEOGRAPHICAL LOCATION OF THE PROJECT

The Environmental Studies Office will proceed with the presentation of the location on a topographical map, or a recent site plan to a carefully determined level. The project location should appear on the map, highlightings the total area of the site granted or acquired by the owner, the access roads, facilities or types of activities adjacent to the site and the sensitive and / or vulnerable elements in the surrounding environment.

III.2.3 - JUSTIFICATION OF THE CHOICE OF PROJECT SITE

The Environmental Studies Office will conduct a justification for selection of the project site. The Environmental Studies Office will present the precise environmental criteria used to choose the site.

In other words, it will assess the environmental, social, technical and economic benefits of the chosen site. This justification will take into consideration:

- Physical constraints;
- Possible technical and financial constraints;
- The extent of certain impacts associated with them (risks to health and safety, incompatibility with the uses, etc.);
- Social and economic constraints (major concerns, economic, employment sources, etc.).

III.2.4 – DEVELOPMENT PLAN OF THE PROJECT SITE

The Environmental Studies Office will develop a management plan for the project site.

III.2.5- DESCRIPTION OF THE PROJECT IMPLEMENTATION PROCESS

Technology Overview

The Environmental Studies Office will briefly present the advantages and disadvantages of the main technologies being considered by OCCIDENTAL GOLD, taking into account the technology that appears more favorable to the protection of the environment. This presentation includes both production technologies as those relating to Mitigation or eliminating impacts.

This technology description should highlight the innovations in the exploitation (mining and processing) of ore.

Description of technical characteristics

Once the technology was chosen, the study will describe all the known and predictable characteristics associated with the project, including activities, facilities and planned work during the different phases of the project, as well as facilities and equipment major retained.

This description should cover the entire project, from ore extraction, crushing or grinding, through the production process, up until the release management mode, including warehousing, transportation and waste disposal and other waste.

All activities likely to cause emissions of environmental contaminants will then be listed, described and localized, as well as the means and mechanisms to reduce the presence of contaminants in the environment.

Description of the different project phases

The Environmental Studies Office will present the different project implementation phases, namely:

The development, earthworks and construction phases

- management of activities (deforestation, land clearing, excavation, backfilling, removal of topsoil, use of heavy machinery, etc.);
- the construction of facilities and other temporary infrastructure (access road, staff accommodation, administrative offices, parking lots, etc.);
- management of ore (volume, location, collection, transport, storage, etc.);
- management of runoff and drainage water (collection, control, bypass, containment);
- buildings and other permanent structures and related facilities (roads, energy carrier systems, water intakes
- processes and ore processing equipment, process diagrams and mass balances for each stage of production and waste management;
- raw materials and additives (quantity, characteristics, acceptance control program, transport, storage, etc.);
- sources of energy (electric power);
- reception areas, handling and storage, etc.).

Operating phase

- Closure and Rehabilitation Phase
- commitment to prepare, some years before the work stoppage, the closure plans of facilities,
- the management of the closing activities of the project site.

During these phases, the following elements will be determined and characterized by the Environmental Studies Office:

- the timetable for each phase;
- the construction period (date and sequence usually followed);
- the required manpower and daily working hours;
- material resources.

Description of waste and pollution

For both development activities and construction and operation phases, the Environmental Studies Office will make a description of the facilities, waste disposal techniques, effluent treatment (liquid waste, solid and gaseous and sources of pollution) and the methods of control. Process diagrams are used for descriptions. It will indicate the final destination of each waste and effluent.

In addition, the study will demonstrate the ability to meet the standards, criteria and discharge requirements. The management of these systems should aim to source reduction, reach the "minimum discharge" and maintain a continuous improvement program.

A map / diagram of the entire facility will be provided and an assessment of the project cost must be provided.

III.3 - DESCRIPTION OF THE INITIAL STATE OF THE SITE

The description of the environment is important because a project is evaluated not only according to existing regulatory standards, but also according to the characteristics of the environment, especially the water, air and soil, as well as living species, their habitats and human communities. This section of the EIS includes selecting a location, boundaries of a study area and description of the components of the relevant natural and human environment project.

III.3.1 – DETERMINATION OF THE STUDY AREA

The definition of a study area is necessary, even essential, to identify all those directly or indirectly affected by the project and to assess the scope of data to be collected (surveys, measurements, surveys, interviews to do).

A map will identify the major geographical units forming the regional context of the project.

The Environmental Studies Office will determine the project area that will include the selected site and the surrounding areas where the influence of the project and the direct and indirect environmental impacts of work to be done can be felt on the natural, human and socio-economic environment.

Moreover, the limits are considered as anticipated impacts, with Mitigation measures.

III.3.2 – DESCRIPTION OF THE COMPONENTS OF THE ORIGINAL PROJECT ENVIRONMENT

Based on available data, supplemented by quantitative and qualitative inventories, the Environmental Studies Office will describe the the relevant components of the environment, both biophysical, socio-economic and human, in relation to the issues and impacts.

It must take account of any anticipated changes that may occur before the project begins. For this purpose, any project in progress or planned in the area will be described where relevant.

The Environmental Studies Office will describe the components of the environment through the following:

- Physical environment: climate, geology, geomorphology, topography, soil science, hydrogeology, surface hydrology.

- Biological environment: flora, fauna, rare or endangered species, natural habitats and sensitive habitats. The Bureau of Environmental Studies will describe the vegetation cover and the different types and groups of animal species, and will, highlight, endangered species or any constraints threatening the flora and fauna.
- socio-economic and cultural environment: habitat areas, human settlements and trends in new habitats, state of infrastructure and basic facilities demography, ethnic groups and social organization, sectors and their relative importance, sources of income, means production, use and ownership of land, food and water use, control resource use, transport characterization, cultural heritage, etc.

In particular, the study will:

- Specify the demographics of villages Sissingue, Kanakono, Tialaka and Basso;
- Describe the current forms of occupation and the occupiers of land in these villages, including Sissingue and Kanakono located in the direct impact area of the project and around them, as well as the activities carried out these lands.

III. 4 -.IDENTIFICATION AND ANALYSIS OF POTENTIAL IMPACTS

This section covers:

- The identification and analysis of impacts

- Assessing the importance of project impacts during the various phases of project implementation.

III.4.1 – IDENTIFICATION AND ANALYSIS OF IMPACTS

The Environmental Studies Office will proceed with the identification and impact analysis across a description of the relationships between the project (sources of impact operations) and the different components of the environment (elements of the receiving environment affected). The Environmental Studies Office will describe the tools or methodologies used: matrices, networks, etc. and explain the choice. It also will analyze these impacts identified to categorize as they are positive and negative, direct and indirect, and, if appropriate, determining the cumulative, synergistic and irreversible impacts associated with the project.

In other words, this part of the study includes an analysis of direct and indirect foreseeable consequences of the project on the environment and especially on resources and natural environments on sites and landscapes, biological balance, the frame of life of the population.

In accordance with the methodological approach required for an impact study, the impacts will be classified by distinguishing phases of project implementation work:

- The preparation stage or development of the site,
- The construction phase of the facilities,
- The operational phase of the project,
- The closing phase or rehabilitation of the project site.

The table below lists the key aspects to consider in identifying and analyzing impacts.

TABLE Impact Assessment

Site of the project:
Describe how the environment, its resources and habitats will be modified by the project and how these changes will affect the habits of people living in the affected areas.

Project construction phase:
Consider the ecological and social changes induced by the delivery and installation of equipment and materials for the project.

Impacts associated with the influx of workers, risk of accidents, pollution and changes in the living environment of residents and natural areas crossed will be taken into account.

Operational phase:

Analyze the impacts of the extraction and transportation of minerals on the natural landscape, topography, erosion, water quality, air quality, acoustic environment, fauna and flora, behavior of living things, health and safety, the potential use of land resources by the inhabitants;

Analyze the direct and / or indirect impact of mining and mineral processing on the environment (flora, fauna, water resources, etc.), hygiene, health and safety.

Analyze the impacts associated with the influx of workers, risk of accidents, pollution and changes in the living environment, pollution risks.

Regarding impacts on the natural environment, the study should pay particular attention to the presence of Bagoé river.

Social plan:
Highlighting the benefits for local populations in general and the most vulnerable social groups (women, youth) in particular.

Analysis of options selected by the promoter of social policy for the benefit of local people.

Social Risk Assessment:

The project will lead to an intermingling of indigenous peoples with foreign people attracted to work opportunities or induced by the project. This new situation could cause risk of spreading diseases. Also in the operation phase especially, a project of the nature of the one in question could lead to social deviations (alcoholism, etc.). The Environmental Studies Office will analyze these problems in the study.
The Office of Environmental Studies will summarize in a matrix, shown below, all significant impacts on each component of the environment (physical, biological, socio-economic background).

Matrix of Impacts

Phase of the project	Zone	Activity/source of impact	Affected environment	Nature of the impact

III.4.2 – ASSESSMENT OF THE IMPORTANCE OF IMPACT

The evaluation of the significance of an impact depends on both the affected component, the intrinsic value to the ecosystem (sensitivity, uniqueness, rarity, reversibility), as well as social, cultural, economic and aesthetic of the population with regard to the affected component.

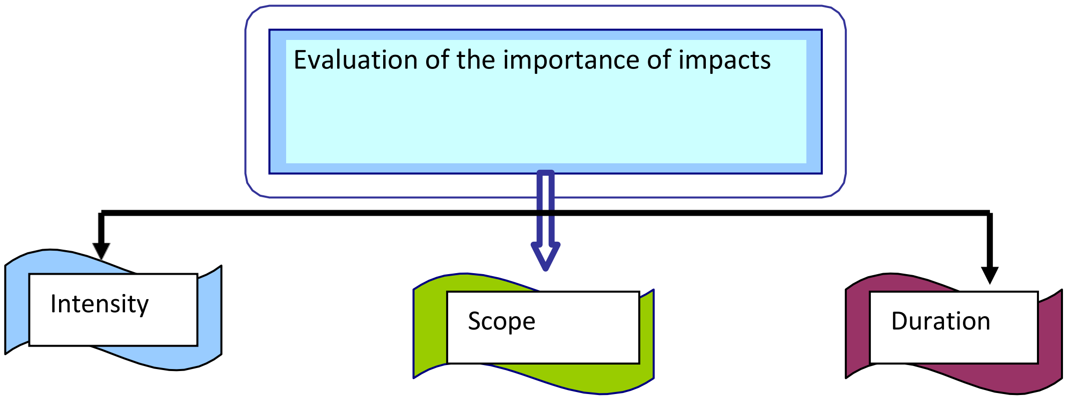
The Environmental Studies Office will assess the significance of impacts using a method and appropriate criteria for classifying the impacts according to various levels of importance.

The criteria to consider are:

- The intensity or magnitude of the impact,
- The breadth or scope of the impact,
- The duration of the impact.

Based on these criteria, the Office of Environmental Studies grade each impact through assumptions that it should explain.

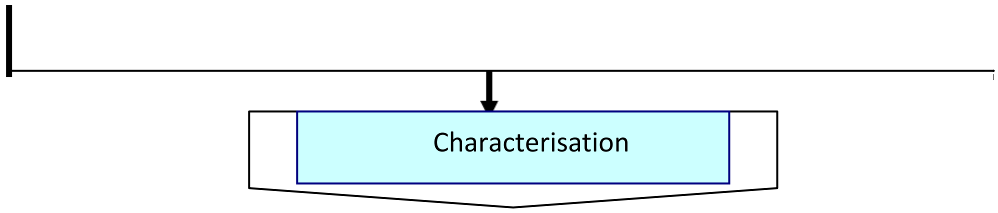
Based on the assumptions and criteria of assessment, the Environmental Studies Office will determine a level of significance of the impact as the impact is minor, major or Average. The diagram below may help to highlight the proposed methodology.



Low Onsite Short

Average Local Medium

High Regionale Long



Minor Importance

Average Importance Major Importance

The matrix below shows the general layout. This presentation should concern each project phase.

Phase of the project	Zone	Activity/source of impact	Affected Environment	Nature of the impact	Impact Assessment			
					Intensity	Scope	Duration	Importance of the

III.5 - PROPOSAL OF ENVIRONMENTAL PROTECTION MEASURES

Environmental protection measures include the mitigation of project impacts. This chapter in the realization of the Environmental Impact Assessment, has three main objectives:

- Look for the best alternatives;
- Define a coherent program of action to mitigate or reduce the most significant negative impacts or to compensate the damage suffered by those affected by the project;
- Seek environmental viability of the project for sustainable management of structures and equipment carried.

In other words, environmental protection measures must be technically feasible, economically appropriate and socially acceptable. The Environmental Studies Office must seek to optimize these measures, so that the effectiveness of one does not interfere with that of the other and no action because she even other negative impacts***.***

These measures may be general or specific. The general measures will be to mitigate the negative effects of the project as a whole. The specific measures will mitigate the impacts on a component of the environment in particular.

General measures

They may include:

- Providing a mechanism for consultation with local communities to promote the harmonious integration of the project into the social and economic environment.
- Preserving the unique strengths of local or national interest.
- Proposing a management system for all liquid waste, solid, toxic products by the activities.
- Training / educating all staff on behavior with minimum impact on the environment.
- Training / educating all staff on the risks and dangers associated with the products used in production.
- Designing and implementing security measures (access limitations, security installations, storage of toxic and dangerous products, risk management program, security measures review program established, if necessary) and emergency plan to avoid all risks and dangers during operations.
- Training all staff on these security measures and emergency plan.
- Establishing schedules.

Specific Measures

- In terms of the environment, for example, the study will:
    - Specify the actions and structures, corrections and additions planned in different phases, to prevent, reduce or eliminate negative impacts. If appropriate, the study will describe the measures envisaged to enhance or optimize positive impacts.

- For the residual impacts, the presentation of compensation.
- In particular the study will propose a rehabilitation plan adapted to the area at the end of the operation.

• Socially, the study should offer compensation. The Environmental Studies Office will therefore explore the possibilities of identifying essential needs (farming, land holdings, etc.) and propose a method of compensation through the implementation of the Travel Plan and Resettlement of affected populations. Indeed, due to its location, the project will result in loss of property of the population (farming, farmland, habitats, etc.).

All recommended measures on controlling the impacts will also be synthesized by the Environmental Study Office in a matrix, giving a synoptic view of the situation described for each component of the environment (physical environment, biological environment, human environment) :

Summary matrix of the recommended measures

Phase of the project	Zone	Activity/source Of impact	Affected Environment	Nature of the impact	Recommended mitigation measures

Furthermore, the study will assess, as far as possible, the costs for these measures of prevention, mitigation, compensation and proposed optimization

III.6 - MANAGEMENT OF RISKS AND ACCIDENTS

The implementation and operation of this project can be the cause of accidents with major consequences. The Environmental Study Office will analyze the dangers associated with the project, will present an overview of accidents in past similar project will establish scenarios of potential major accidents, considers consequences, frequency and risk. This analysis will consider the legislation, regulations and codes of practice which must comply with the proposed project. The labor code requirements in Ivory Coast will be of paramount importance in this analysis. During the analysis of these risks, the Environmental Study Office will pay special attention to sensitive environmental features that may be affected during an accident.

Specifically, the Environmental Study Office will include:

• risk estimation regarding the following aspects:

  - Risk of accidents when using loading gear, processing ore and transport equipment as well as treatment;
  - Risk related to the explosion in the use of explosives, etc;
- the development of security measures (presentation of security measures on the operating site, including related facilities located outside the main location):
  - Access to the project site limitations;
  - Maintenance program and monitoring the integrity of the site;
  - Risk management program;
  - List of rules or practices as reference codes.
- developing an emergency action plan in case of accident. This plan must identify emergency situations and responses in emergencies. This plan should include for example:
  - The security measures in force at the site;
  - The internal intervention structures, emergency and decision-making mechanisms;
  - The method of internal and external communication, etc.

The Environmental Studies Office will present an Internal Operations Plan (POI) summary that will include the following:

- movement or displacement on site
- personal protective equipment,
- the guidelines on employment and movement of vehicles,
- protective measures against the dangers of machinery,
- measures related to good practice against noise,
- staff training,
- simulation drills plans in case of disaster,
- fire fighting

The presentation of these aspects listed above will enable the Environmental Engineering Department to do an analysis of the environmental policy of the promoter (OCCIDENTAL GOLD). This will include safety, health and environment policies, highlighting the code of good and safe environmental practices, specifying the internationally recognized standards available having served as a basis for the implementation of this environmental policy.

III.7 – DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) aims to establish a program for the monitoring and sustainable management of the impacts of planned work during the different phases of the project.

The major objective of improving the environmental conditions of the project, is to propose an Environmental Management Plan which puts into operation the recommendations of the EIA. Therefore, the Office of Environmental Study will describe the mechanisms (actions required) to ensure compliance with environmental requirements and the functioning of the works, equipment and facilities and the monitoring of the evolution of certain components natural and human environment affected by the project.

The Office of Environmental Studies distinguishes two aspects in the EMP: management and monitoring. It will define the objectives of each aspect and define the bodies responsible for their implementation.

The Environmental Management Plan developed by the Environmental Studies Office will present the environmental monitoring indicators for observing changes to the previously defined objectives.

The Environmental Management Plan will also be established with the intention of reconciling the logistical and financial resources to implement and desirable outcomes.

The plan will highlight the different partners and their responsibilities. The Environmental Studies Office must indicate the teams capable of performing the actions proposed in the Environmental Management Plan; summarily assess their capabilities and identify the need for capacity building and institutional improvements.

A summary matrix will be developed by the Environmental Research Office and will consider the following aspects: the impacts and mitigation measures for the different implementation phases of the project and relevant and appropriately identified environmental indicators. This is presented below.

Ministère de l'Environnement, des Eaux et Forêts /Agence Nationale De l'Environnement (ANDE)

Matrix of an Environmental Management Plan

Phase of the projet	Zone	Activity/ source of	Affected Environment	Nature of the impact	Mitigation Measures	Responsible for execution	Responsible for monitioring	Environmental monitoring indicators	Cost	Source of funding

Projet aurifère de TENGRELA, présenté par OCCIDENTAL GOLD Termes De Référence de l'Etude d'Impact Environnemental (avril 2009)/ ***TDR n°8-0604-09***

III.8 – PUBLIC PARTICIPATION

A project designed in the context of sustainable development must incorporate the principle of social equity, as well as environmental protection and economic efficiency. On this basis, the participation of citizens in the process of planning and decision making is required in the implementation of development projects.

It is important to begin consultation as early as possible in the planning process. The more consultation takes place early in the process that leads to a decision, the greater the influence of citizens on the whole project and the more the project is likely to be socially acceptable.

In the case of this project, the Environmental Engineering Department will specify the extent of the consultations he has undertaken to collect the views and concerns of all interested parties in the project.

To this end, an effective process of information and consultation of people in direct and indirect areas of influence of the project will be set up. Information meetings and public consultations must be held before and during the preparation of the Environmental Impact Study. Only a participatory approach will lead to equitable development of the project and included solutions and accepted by all.

The Environmental Studies Office will outline the concerns and expectations of the people on the project, the controversial elements that have been raised and responses to concerns.

EIA therefore take well into account the views, reactions and the main concerns of individuals, groups and communities including the Union of Youth Sissingue, association executives Kanakono.

The results or minutes of these consultations must be appended to the Environmental Impact Assessment report.

DURATION OF THE STUDY

The likely duration of the study is at the discretion of the contractor, OCCIDENTAL GOLD. The Environmental Studies Office will propose an implementation schedule of the study taking into account the following indicative areas:

- Consultation of local administrative authorities,
- Socio-economic surveys,
- The agricultural census,
- The development of Displacement and Resettlement Plan for populations affected by the project,
- The acquisition of physical and biological data,etc.

TEAM OF EXPERTS

The study must be conducted by an Environmental Studies Office approved by the Ministry of Environment, Water and Forests. The experts required for completion of the study will have sufficient qualification and justified at least five (5) years of experience to the EIA team leader and three (3) years for other experts. Experience in education or related projects is required.

The team responsible for the development of the impact assessment will consist of the following profiles:

EXPERTS	ACTIVITIES
EIA Specialist	Coordinate the activities of team members and drafting of the various progress reports. In particular, it will guide the team members on the activities to be considered. It will specify the methodology to implement and organize exchanges.
Engineer	Study of the relationship between mining and the various components of the environment through the identification of potential negative impacts and the proposed remedies. Development of Emergency Plan
Hydrogeologist	Study of groundwater levels and different supply sources (wells, boreholes)
Hydrologist	Study the watershed of the river basin Bagoé. Presentation of quantitative assessment of water resources in the project area
Botanist	Inventory of flora and impacts of the project on plant communities
Zoologist	Inventory of wildlife and impacts of the project on wildlife communities
Health specialist	Epidemiological study in the direct impact area of the project and highlighting the impacts on the local communities in relation to the sociologist
Sociologist	Survey to highlight the structuring of space in terms of activities (agricultural land, shops, markets, etc.) and operation of the entire space of Sissingue Description, analysis and evaluation of the significance of project impacts on workers (construction phase) and mine personnel (operational phase) as well as the socio-economic activities in Sissingé in particular and the entire the region in general.
Hydrobiologist	Characterization of rivers Identification of pollution sources in relation to the hydrologist
Soil Expert	Description of soil units. Estimated agricultural land potential Highlighting the potential for soil erosion
Agronomist	Inventory of agricultural land (Census)
Specialist responsible for matters relating to the development of a Displacement and Resettlement Plan population	Responsible for conducting the Displacement and Resettlement Plan or Compensation

CONTENT OF THE REPORT

In drafting the EIA and content of the report, the Office of Environmental Studies should refer to the indicative model in Annex 4 of Decree No. 96-894 of 8 November 1996 laying down rules and procedures for studies on the Environmental impact of development projects:

Non Technical Summary.

Introduction

Objectives of the study;

Leaders of the EIA;

Procedure and scope of the EIA;

National policy on the environment;

Institutional and Regulatory Framework of the EIA;

Methodology and work program.

Project description

Project Sponsor;

Project site;

Justification of the project;

Description of the project and its alternatives (including the situation without project);

Implementation Timeline of activities;

Need for EIA.

Initial state of the environment

- Data collection methods;
- Basic data on the physical, biological and socio-economic context;
- Relations between the project and other development activities in the region;
- Trends in the status of the environment;
- Data Gaps.
- Identification, analysis / prediction and assessment of the significance of impacts induced by the project
- Description and analysis of the potential impacts of project activities on components biophysical and socio-economic (construction and operation phases);
- Assessment of impact significance;
- Comparative assessment of variants;
- Methods and techniques used;
- Uncertainties and knowledge gaps.

  - Environmental protection measures
  - Description of the proposed protective measures (prevention, mitigation, compensation, restoration).
  - Environmental Management Plan
  - Environmental Monitoring Plan;
  - Training and Awareness Program.
- References
- Annexes
  - List of persons interviewed;
  - Public participation (public hearings, public consultations, etc.) ;
  - Communication media (press clippings, written opinions, etc.);
  - Data Field Collection Program;
  - Land Transfer Agreement;
  - Project situation map;

SOURCES OF INFORMATION

General Site Map with the different facilities (Bureau, processing unit, storage, etc.)

The people we met, departments and structures found, the data collection program in the field, written opinions and public participation will be recorded in the study.

The main difficulties encountered in data collection will also be mentioned in this part of the study.

REFERENCES

The Environmental Studies Office cites any other documents used in the preparation of the EIA report.