0.2.3.5 Summary of the VECs for the physical environment

Table 0-4 presents a summary of the VECs and subcomponents for the physical environment.

Table 0-4 VECs and subcomponents for the physical environment

VEC	Subcomponent	Value
Air quality	Particulates and metals	High
	Gases	High
Noise and vibrations	Noise	High
	Vibrations	High
Freshwater	Water quality	High
	Sediment quality	High
Marine waters	Water quality	High
	Sediment quality	High
Groundwater	Groundwater flow	High
	Groundwater quantity	High
	Groundwater quality	High
Soils	Soil as a resource	High

VEC	Subcomponent	Value
	Soil quality	Medium

0.2.4 Identification and evaluation of the main physical impacts and prevention, improvement and mitigation measures

0.2.4.1 Air quality modeling

Air dispersion modeling was undertaken using the CALMET/CALPUFF modeling system - a current state-of-the-art dispersion model - to predict the incremental level of selected contaminants of potential concern (COPCs) (PST, PM_{10}, $PM_{2.5}$, SO_2 and NO_2) within a modeling region or domain. The CALPUFF model has ability to handle both complex meteorology and an array of multiple emissions sources from facilities and activities located over a large area. It is the U.S. EPA regulatory model for long-range transport studies.

In order to overcome the limited observation record in Kamsar and Sangarédi, five years of site-specific meteorology were developed for both sites for the 2009 – 2013 period.

Details on the elaboration of an emissions inventory are presented in the complete air quality assessment report (Annexe 2-1). Detailed modeling by the CALPUFF software was conducted for existing conditions and each extension scenario for Kamsar and the Sangarédi area (see Annexe 2-1). For each assessment scenario the emissions inventory was developed for particulates (TSP, PM_{10} et $PM_{2.5}$), gases (NO_x and SO_2) and the metals in the TSP. Emission factors were used to estimate the maximum emission rates of the specified COPCs for each source and/or activity in each phase of the Project. The emissions were estimated for the plant at Kamsar, the mining areas in Sangarédi and a section of the railroad.

0.2.4.2 Greenhouse gases

The CBG has produced the following analysis for greenhouse gases:

"The CBG GHG emissions represent approximately 3% of the total national emissions (2014). It is important to note that the CBG is the largest private industrial and commercial company in the Republic of Guinea. In 2022, when the production will be 27.5 MTPA, the contribution of the CBG will have increased to 3.6% of the national emissions and then reduce to less than 2.3% at the end of the long-term mining plan in 2042. The contribution of the CBG will be less important than its current contribution, taking into account an annual average increase of 3.1% for national emissions.

The Extension Project will increase local GHG emissions. This increase however will not be directly proportional to the increase in production since there will be improvements in efficiency and productivity related to the Project. We will pass in 2012 to 0.020 tCO_2e/tonne of shipped bauxite to 0.018 tCO_2e/tonne of shipped bauxite for a production of 27.5 MTPA in 2022.

To reduce the impact of the increase of production on GHG emissions, the CBG has committed to several programs to reduce fuel consumption.

Table 0-5 shows the emissions of carbon dioxide (CO_2), of methane (CH_4), and of nitrous oxide (N_2O) as well as the total GHG emissions in equivalent CO_2 (t), for the different phases of the operation following the application of mitigation measures. The emissions for 2012 have been calculated including fuel consumption and data relative to land use (deforestation)."

Table 0-5 Greenhouse gas inventory for different stages of the Project

	Emissions of CO_2 equivalent (t)			
	2012	**18.5 MTPA**	**22.5 MTPA**	**27.5 MTPA**
Kamsar plant	105,500.42	139,920.64	149,011.98	197,316.58
Drying ovens	101,474.12	134,603.99	163,707.55	183,872.16
Mining machinery	31,122.20	40,482.73	46,772.90	54,467.18
Locomotives	22,938.94	25,184.69	28,892.02	34,845.75
Sangarédi plant	18,195.47	20,222.97	22,432.42	23,446.17
Vehicles	4,195.01	4,193.99	4,193.99	4,193.99
Electrical generators	2,353.59	2,353.59	2,353.59	2,353.59
Deforestation	1,919.87	1,919.87	1,919.87	1,919.87
Roads	177.70	274.42	427.64	455.20
Personal allocation	121.48	122.69	120.22	120.22
TOTAL	**287,998.8**	**369,279.6**	**419,832.2**	**502,990.7**
Increase relative to 2012	-	28.2%	45.8%	74.7%
CO_2 equivalent (t) / Tonne de bauxite	**0.01986**	**0.01996**	**0.01866**	**0.01829**
Difference between the various phases and 2012	-	0.5%	-6.1%	-7.9%

0.2.4.3 *Noise and vibration modeling*

A baseline model was developed for the existing site operations at the Kamsar processing facility using Cadna-A software and was based on process and equipment information available in the Expansion Project FEL2 Study Preliminary Engineering Report, source-specific sound level measurement data, and site plans provided by the CBG. This baseline model was validated against the baseline measurement data, and was then adapted as necessary for purposes of estimating the incremental increases in sound level associated with the proposed expansion of the plant.

Points of reception were placed in the model at the actual sensitive properties, which differed slightly from the monitoring locations. The model was executed for each future scenario, and a conservatively low estimate of non-plant background was added to the result to estimate the total future sound level at each receptor. Each scenario was compared to the total sound level for the existing condition to determine the incremental impact of the Project. The increments and the total predicted future sound levels were compared to the IFC criteria.

The Cadna-A model was also applied to predict sound levels from future operations at the proposed mine sites. Given the spatial extent of the areas proposed for mining, it was not possible to complete a separate model for each individual mine site, as they are interspersed throughout an area of approximately 400 km^2. Instead, a series of models were run using typical equipment arrangements that may be present at any given mine site. The model was configured to calculate sound pressure levels at a series of increasing distances from the center of the activity, and the results were used to prepare curves depicting sound level with distance.

The assessment of potential effects from increased rail traffic was completed by developing two (2) acoustic models, each representing unit segments of rail line identical in geometry to that developed for the baseline model. The first model was representative of a typical section of rail with no adjacent siding. The second model was representative of the locations where a new rail siding is proposed, and may therefore have a train passing on the mainline with a train idling on the siding.

The propagation characteristics of ground vibration from blasting are influenced by a number of factors, including the geology of the region, the charge mass being detonated and the distance between the blast and receptors. As propagation is strongly dependent upon geology, and geology is very site-specific, there are no standard models for reliable, repeatable predictions of ground vibration from blasting. Empirical propagation equations derived through experimentation are typically applied in the prediction of ground vibration levels by distance.

0.2.4.4 Zone 1: the mine

Air quality

Tables 0-6 and 0-7 show the maximum predicted annual concentrations of COPCs for each future production level at the air quality monitoring locations along with the percent change in concentration from existing operations. As can be seen in the tables, change in concentrations relative to existing operations is highly variable. The change in concentration not only reflects the change in quantity of bauxite being mined, but the proximity of each receptor to the road network as well as the extraction areas and rail loading areas. This was evident in the contour plots in Annexe 2-1 that show how the shapes of the contours closely follow the road network, particularly for particulate matter concentrations

Table 0-6 Percent change in annual predicted COPC concentrations from existing to 22.5 MTPA: Sangarédi mining operations

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percent Change from Existing		
				PM_{10}	$PM_{2.5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1234.554	234%	255%	25%
AQ-11	AQ-11 Hamdallaye	622.252	1225.617	1400%	1126%	128%
AQ-12	AQ-12 Petoun BW	628.870	1224.203	74%	10%	-76%
AQ-13	AQ-13 Parawi	616.710	1221.796	110%	66%	-4%
SR-46	Hamdallaye	622.082	1225.627	2693%	2119%	362%
SR-59	Carrefour Parawol	631.430	1221.004	10884%	8109%	990%
SR-97	Madina Dian	632.551	1221.418	3570%	2784%	458%

Table 0-7 Percent change in annual predicted COPC concentrations from existing to 27.5 MTPA: Sangarédi mining operations

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percent Change from Existing		
				PM_{10}	$PM_{2.5}$	NO_2

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percent Change from Existing		
AQ-10	AQ-10 Kourawel	620.746	1234.554	4427%	7703%	4799%
AQ-11	AQ-11 Hamdallaye	622.252	1225.617	556%	417%	-43%
AQ-12	AQ-12 Petoun BW	628.870	1224.203	-79%	-78%	-95%
AQ-13	AQ-13 Parawi	616.710	1221.796	85%	66%	-36%
SR-9	Kourawel	620.668	1234.753	2556%	3793%	2046%
SR-10	Sinthiourou Kourawel	620.513	1234.360	4989%	9256%	5997%
SR-46	Hamdallaye	622.082	1225.627	2298%	1759%	69%
SR-60	Kahel M'body	621.990	1235.671	2619%	2760%	865%

Short-term air quality effects on ambient concentrations of particulate matter and SO_2 were assessed by modeling a generic working (or extraction) area together with a generic road in order to represent a worst-case 24-hour emissions scenario. Short-term effects from NO_2 are dominated by the emissions from explosives.

Although it may be possible to attain some supplementary control of particulate and gas COPCs to respond to the short-term guidelines of the WHO, it may be necessary to maintain minimal setback distances between mining activities (including use of explosives) and the villages. Consequently setback distances to meet applicable short-term WHO interim targets and guidelines for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for each of the production levels were also calculated. In the vicinity of a typical road, the model results indicate that the largest setback distance required to meet Interim Target-1 for PM_{10} is 220 m. The largest setback distance required to meet the Interim Target-2 level for $PM_{2.5}$ in the vicinity of a road is 60 m. The largest setback distance required (in terms of NO_2 1 hour) from a blast is predicted to be approximately 600 m.

Noise and vibration

Sound levels attributable solely to mining activity were calculated at a total of 102 villages, based on various activity levels at the nearest proposed work areas. These predictions were added logarithmically to the baseline sound levels from the baseline monitoring program, to arrive at total future sound levels. The future sound levels were compared to the baseline condition to determine the increment, which was compared to the IFC criteria of 3 dB and the impact ratings. The future sound levels were also compared to the absolute IFC criteria. Exceedances of the absolute and/or relative criteria were predicted at a number of villages, as summarized in Table 0-8. Details and the villages concerned are given in Chapter 2 (Volume 2 of the ESIA) and in Annexes 2-2 to 2-8 (Volumes A and B).

Table 0-8 Number of villages predicted to exceed IFC criteria for nearest work area

Scenario	Daytime (07:00-22:00)		Night-time (22:00-07:00)	
	No. of Villages Exceeding Absolute Limit (55 dBA)	No. of Villages Exceeding Relative Limit (<3 dB)	No. of Villages Exceeding Absolute Limit (45 dBA)	No. of Villages Exceeding Relative Limit (<3 dB)
1 working area	40	39	63	43
2 working areas	48	48	74	54
3 working areas	53	53	87	67
Note: total number of villages modeled was 102				

The setback distance that would be required for the prediction results to comply with the IFC criteria (both absolute and relative) at each village was calculated (see Annexe 2-6). The calculated setback distances for daytime and nighttime hours have been plotted as a radius around the associated village. Work at any of the proposed mining areas that appear within the displayed setback radius are predicted to result in an exceedance of IFC criteria at the associated village.

For the blasting impacts, propagation equations were instead solved for the charge mass per delay at a number of distances. When plotted, the resulting curve can be used to establish the maximum charge mass per delay that may be used at any given distance to comply with the limits. These plots are provided in Chapter 2. The CBG will use the information in these plots to limit the charge mass per delay at any given location to achieve both the ground vibration and airblast overpressure limits.

Water and sediments

The predicted annual average dust deposition rates over land at Sangarédi will go up as production increases with the exception of the 27.5 MTPA scenario. Although the predicted concentrations are higher in the 27.5 MTPA scenario, the area of impact is smaller and thus the average value is lower than the other scenarios. It is acknowledged that there is the potential for a larger impact on some of the smaller rivers; this risk is expected to be highest in the 27.5 MTPA scenario due to the higher concentrations.

A (quasi) mass balance approach was used to assess the impacts of the increased dust deposition (and its metallic constituents) to the surface water quality of the water bodies in the Sangarédi mine area. This screening-level assessment indicated that it is possible that the project will have an influence on water quality in the area, particularly for aluminum. It is noted that impacts may be more significant to smaller rivers and streams due to lower flow rates; however, these effects would be localized.

The predicted levels for concentrations of various metals from aerial deposition in the Cogon should remain low, apart perhaps for aluminum. There is a possibility of impact from the aluminum levels in the waters of the Sangarédi area.

The water quality guideline for aluminum used in the assessment is 87 µg/L from the U.S. EPA. This value is based on toxicity tests with the striped bass in water with pH 6.5–6.6 and hardness <10 mg/L. There is potential for this value to be approached or exceeded in the expansion scenarios, particularly the 22.5 MTPA scenario. The mobility and availability (therefore toxicity) of aluminum is highly influenced by pH and presence of dissolved organic carbon (see Annexe 2-10). It is also noted that temperature can have an effect, at low temperature (2°C) aluminum species are expected to remain in their most toxic form compared to that which would occur at higher temperature (20°C).

Currently aluminum concentrations in sediment range from 32,000 mg/g to 76,000 mg/g without any obvious spatial distribution. These concentrations are within the range of values measured worldwide (WHO 1997). If there are changes to the water quality, this could also influence sediment quality, particularly in areas where there may be deposition. Considering that this is an active mining area and, although data are limited, there is no obvious indication of impacts on sediment to date, it is not expected that there would be widespread changes to the aluminum levels in sediment as the Project progresses; however, localized areas of increased aluminum in sediment may occur.

Potential acidification of surface water due to emissions of SO_2 and NO_2 was also considered. Although the air quality assessment showed that there are short-periods of high concentrations, the annual average concentrations are low. Hence it is not expected that the operation would have an effect on the pH of the water.

There are potential positive effects on groundwater flow and quantity due to the potential for increased infiltration of precipitation into the subsurface due to the exposure of subsurface soil from mine excavation activities. Blasting activities can also increase infiltration by creating surficial fractures in the soils/laterites. In the absence of a vegetated surface, infiltration directly into the subsurface can be expected to be greater under the post-extraction scenario.

The groundwater quality could be affected by the current mining activities through infiltration of precipitation into the soil, facilitated by the creation of soil fractures from the blasting. Explosive residues could therefore more easily lead to groundwater contamination by infiltration after a rainfall. The Project will increase the frequency of the blasting. Although this could represent an additional risk for groundwater contamination, the impact is considered low.

Soil

There are three types of soil impacts to consider for the mine area:

- The stripping of soils on the site of new quarries and mining roads;
- Soil erosion on the new quarries and mining roads; and
- Aerial deposition due to dust and gases on the areas close to construction or operation;

The major impact is the stripping of at least 3,200 ha of soil during the development of new quarries. These soils are critical for revegetation and future agricultural uses. The stripped soil contains a veritable bank of seeds of native plants already adapted to the local conditions.