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5.0 Environmental and Social Baseline

5.1
Areas of Influence

Following the premises in Resolução CONAMA 001/86 and in specialized literature about the definition of areas of influence in environmental studies (MÜLLER-PLANTENBERG & AB'SABER, 1994; SANTOS, 2004; SANCHEZ, 2006; among others), the delimiting of areas of influence for a potentially impacting project or activity must be understood as a direct result of the surveys and analyses defining the Environmental Baseline study and the ensuing environmental impacts; in this specific case, those of the PROJECT ARRAIAS.

Specific areas of influence were defined according to the following guidelines:

The **directly affected area (DAA)** is defined as the sum of areas undergoing direct intervention in any of the phases in the Project's lifecycle. For the PROJECT ARRAIAS, this will comprise approximately 14,93 km² (1,493 ha) and encompass the projected reservoir areas (tailings and water catchment), mining areas, landfills, access areas and the industrial unit. Additionally, access roads to the Project's areas may have to be widened, and additional temporary access roads may also have to be built; both of these actions may lead to the addition of areas which may be directly affected by the project.

Specifically for ichthyiofauna and aquatic organisms, the DAA is restricted to the water catchment and tailings reservoirs and a small stretch of the Córrego Tiúba basin (close to the fountainhead).

For the social environment the DAA is represented by the reservoir areas (tailings and water catchment), the landfill area and the 300m buffer around the mining areas and the industrial unit. This area includes 49 rural properties included in the area of the Arraias municipality in the state of Tocantins.

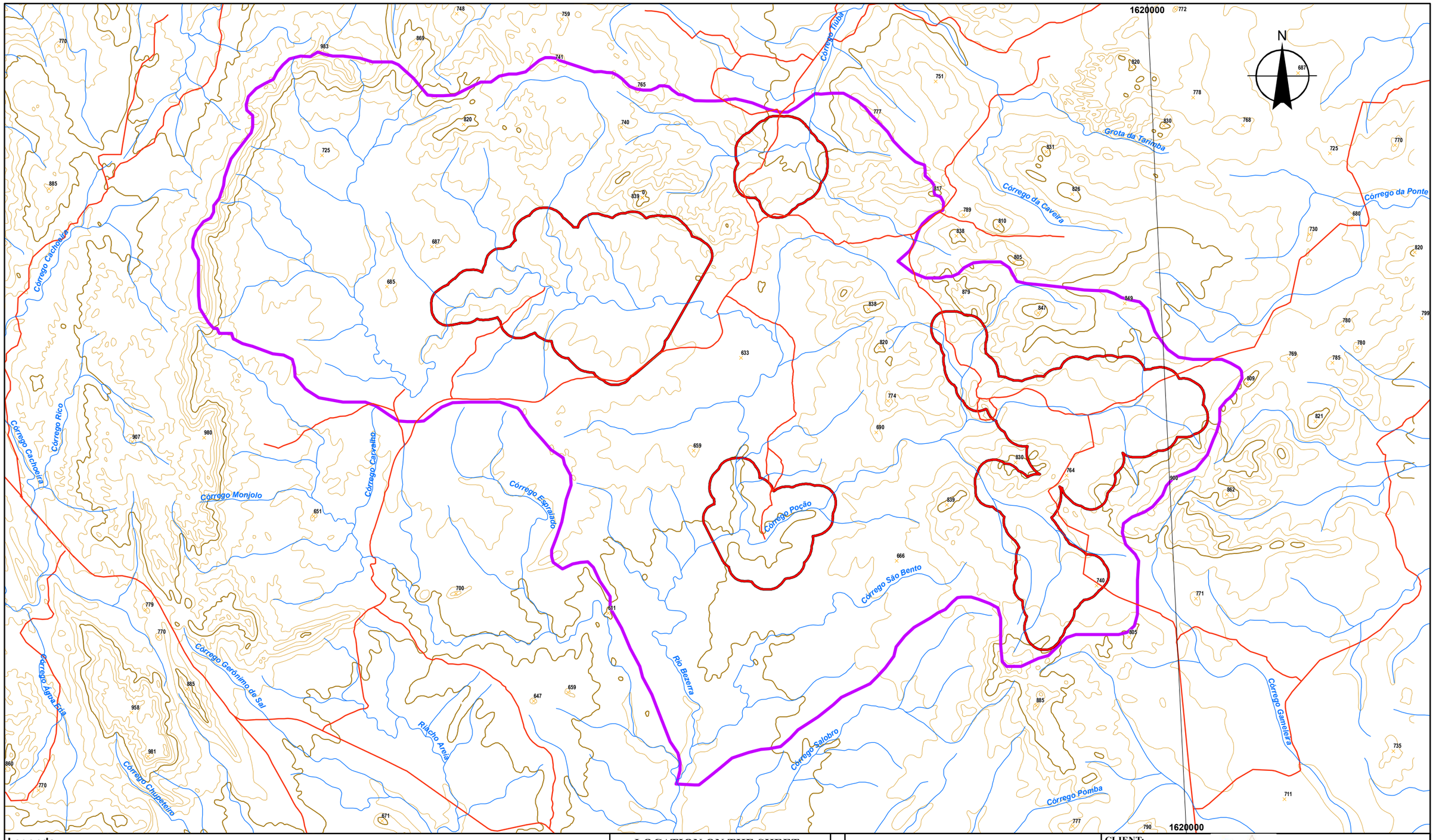
The **direct area of influence (DAI)** is defined as that where direct impacts of the Project may be sensed. For physical and biotic environments the DAI is represented by the Bezerra River watershed up to its confluence with the Córrego Carvalho and the headwaters of Ribeirão Tiúba (including mining areas in Cana Brava), encompassing approximately 221,4 km². Due to the existence of a karstic aquifer (Bambuí Karstic Aquifer System) and the possibility of it exceeding the natural limits of the local drainage divides, surface- and groundwater quality and limnology data were also obtained to the east-northeast of the DAI's limits. For the terrestrial fauna the DAI's definition coincides with the one above, and sampling points are spread throughout the area; additionally, terrestrial fauna sampling will also be carried out in areas beyond the DAI's limits for use as control points in comparisons with sampling points inside the DAI.

Ichthyiofauna surveys in the DAI are restricted to Rio Bezerra and Córrego Poção (near the industrial unit), beyond the Córrego Tiúba basin. A single sampling point is located beyond the DAI's limits for use in comparisons with other points in the Project's DAI (control point).

For the social environment, the DAI corresponds to the Arraias municipality, in the state of Tocantins, where the Project is located, and also the municipality of Campos Belos, in the state of Goiás, which is included in the Project's DAI due to its proximity to the Project area.

The **indirect area of influence (IAI)** is characterized as that where indirect effects of the Project may be noticed. For the physical and biotic environments, the IAI is defined as the Rio Bezerra watershed up to its outfall in Rio Paranã and the sub-basin of the Ribeirão Tiúba, with a total area of approximately 1.854 km². For the anthropic environment, the social and economical impacts will occur in a greater scope within the territory of the Arraias (TO) and Campos Belos (GO) municipalities.

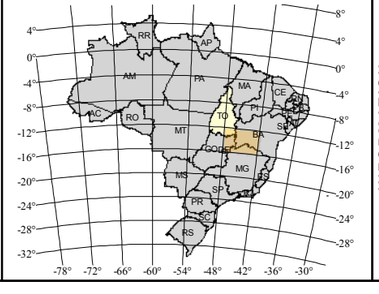
The Project's areas of influence for the physical, biotic and social environments are presented in **Figures 5.1.a. and 5.1.b**



Legenda

- Elevation Points
- Hydrography
- Roadways
- Master Curves
- Intermediate Curves
- Directly Affected Area (Physical Environment)
- Direct Area of Influence (Physical Environment)

LOCATION ON THE SHEET



INFORMATION

Source: Information obtained from environmental Impact Assessment - July 2010

Scale: 1:75.000

0 0,375 0,75 1,5 2,25 3 3,75 4,5 km

Projection - Universal Transverse Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

Date: 01/04/2011 | **Fig. JGP: Figure AID and ADA.mxd**

CLIENT: ItaFós mineração

PROJECT:

PROJECT ARRAIAS

FIGURE 5.1.a:

DIRECT AREA INFLUENCE AND DIRECTLY AFFECTED AREA MAP

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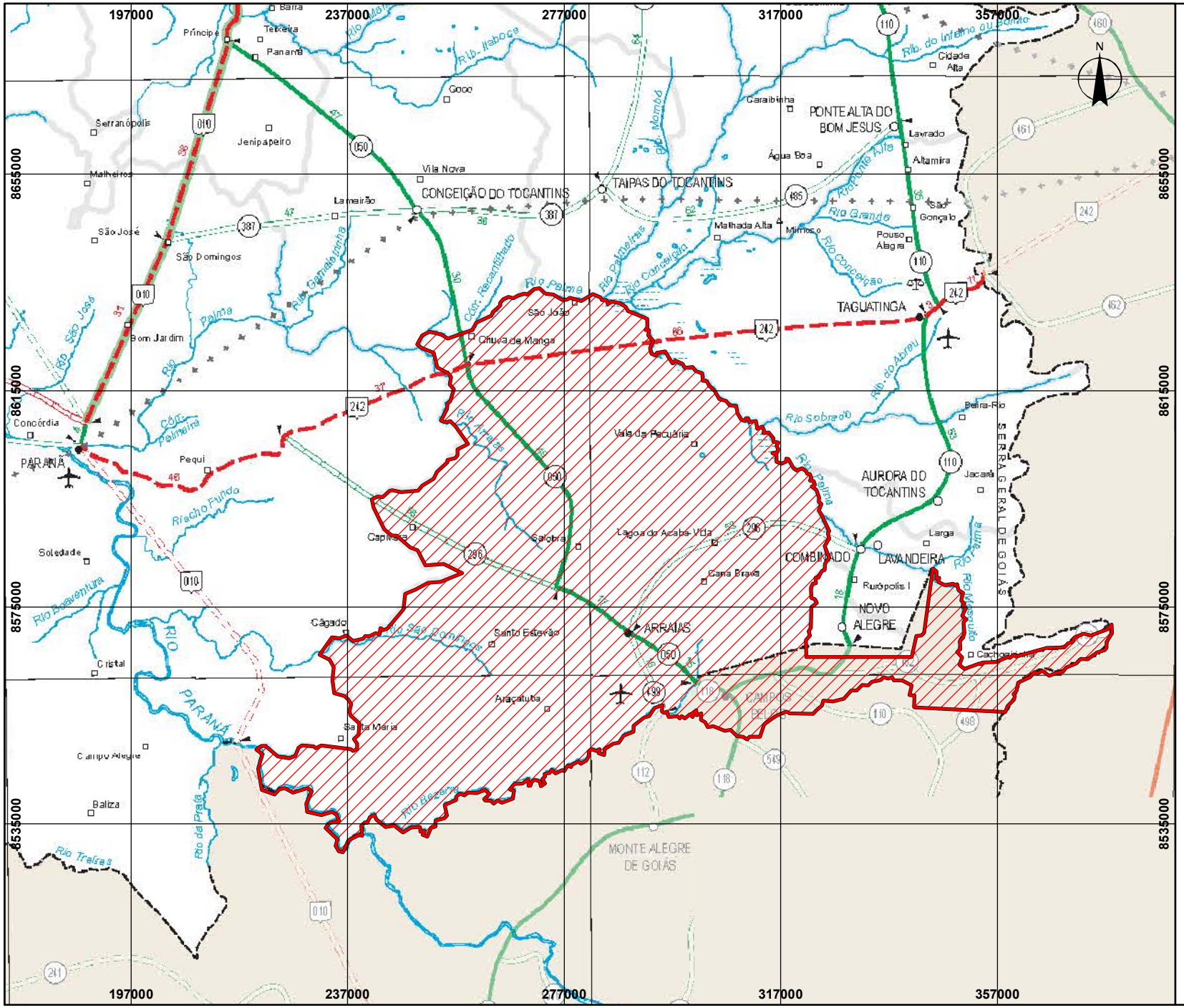

Figure 5.1.b:

INDIRECT AREA OF INFLUENCE MAP

JGP Consultoria e Participações Ltda.

CLIENT: ItaFós mineração

PROJECT:

PROJECT ARRAIAS

Nº DES. JGP: Figure AII.mxd

DATE: 01/02/2011

1:1.000.000

0 5 10 20 30 40 Km

Projection - Universal Transverse de Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

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5.2
Environment Baseline

5.2.1
Physical Environment

Regional Setting

PROJECT ARRAIAS is located in the extreme southwest of the state of Tocantins, near the border of the State of Goiás. In general, topography varies from flat to smooth and ondulating siltstones and limestones with elevations of granite and quartz rocks. Dolomite bodies make up elevations with typical karst dissections.

The area is drained by the Bezerra River and Poções Creek, tributaries of the Paranã River, as well as the Tiúba Creek, a tributary of the Palma River. All these bodies of water flow towards the Tocantins River, which, in turn, is a tributary of the Amazon River.

5.2.1.1
Climate and Meteorology

According to the climate classification adopted by Nimer (1989), the state of Tocantins is dominated by a Hot Climate. Summer has high rainfalls, much due to tropical squall lines. Autumn marks the end of the rainy season and transition to the beginning of the driest months that occur in winter. In this period the region is dominated by dry winds from the NE, with very low precipitation rates, tending to zero in July and August. October marks the beginning of spring and gradual return of the rainy season, which reaches its peak in December and January.

The region is characterized by high temperatures with little variation during the year. Rainy summers include torrential rains, with daily totals that can reach values higher than 90mm. During winter, from June to August, it is typical to have absence of rain.

Climate data has been compiled from Taguatinga Conventional Station (geographic coordinates 12°24'S and 46°25'W, 603 m in altitude and 70 km northeast of the study area), Paranã Automatic Station (geographic coordinates 12º37' S and 47º59' W, 275 m in altitude, about 140 km northwest of the study area), both belonging to the National Methereological Institut - INMET; and from Campos Belos Station, located near the study area.

Wind data obtained at Taguatinga and Paranã stations refers to 2009. At Taguatinga data indicates weak to moderate winds, with maximum speed of 5m/s (18 km/h), predominantly from the northeast. At Paranã station, light winds with a maximum speed of 1.3 m/s (5 km/h) were observed, predominantly from the southeast.

Average temperatures indicate two distinct periods: hot spring and summer and dry winter with little drop in temperature, characterizing a small annual thermal temperature variation.

5.2.1.2
Air Quality and Noise

Air Quality

Air quality in the PROJECT ARRAIAS development study area and its surroundings was analysed by sampling the concentrations of total suspended particles. To check air quality in the region, two (2) monitoring campaigns were performed for a period of four (4) consecutive days, and each sampling had a duration of 24 (twenty four) hours. The first sampling campaign was conducted from February 23 to 26, 2010 (rainy season), and the second from June15 to 18, 2010 (drought season). The results in the first phase will serve as a basis for comparing with future monitoring within the limits of the area.

In each monitoring campaign 3 (three) Hi-Vols were installed at representative points located near 3 residences, in the vicinity of the industrial complex and near the future PROJECT ARRAIAS mining areas.

The results showed that in both monitoring campaigns, concentrations of suspended particulate matter at the three sampling points are within the daily limit of 150 μg/m³ defined by the CONAMA Resolution 003/90 and the IFC air quality concentrations.

Noise Levels

In order to characterize noise levels in the study area, the monitoring of noise levels (sound pressure level) was conducted in two measurement campaigns according to Standard ABNT NBR 10.151/2000 (ABNT, 2000).

The noise level monitoring campaigns were conducted on March 23 and 24, 2010, and on June 16 and 17, 2010. In each measurement campaign, 18 (eighteen) monitoring points were distributed close to where the plant will be established and access roads to mining areas, water catchment basin and tailings dam.

In the first campaign, the results indicate a minimum background noise of 24.4 dB (A) and a maximum of 50.3 dB (A) in daytime measurements, and a minimum of 23.7 dB (A) and a maximum of 40, 8 dB (A) in nighttime measurements. In the second campaign, the results were a minimal background noise of 30.5 dB (A) and a maximum of 52.5 dB (A) in daytime measurements, and a minimum of 30 dB (A) and a maximum of 35.5 dB (A) in nighttime measurements.

Threshold levels for outdoor environments, according to Standard ABNT NBR 10.151/2000 for areas of farms and ranches, is 40 dB (A) during the day and 35 dB (A) at night.

The results obtained for the noise level monitoring, as well as onsite inspection, showed that the main noise sources in the study area are due to the passage of light and heavy vehicles on access roads between villages and the municipality of Arraias and the machinery that was doing a survey in the region. Before Project implementation it will be determined whether there is a need for additionalmonitoring points or relocating of the existing ones depending on the presence of any potential not previously recognised noise recipients in the Project´s area of influence.

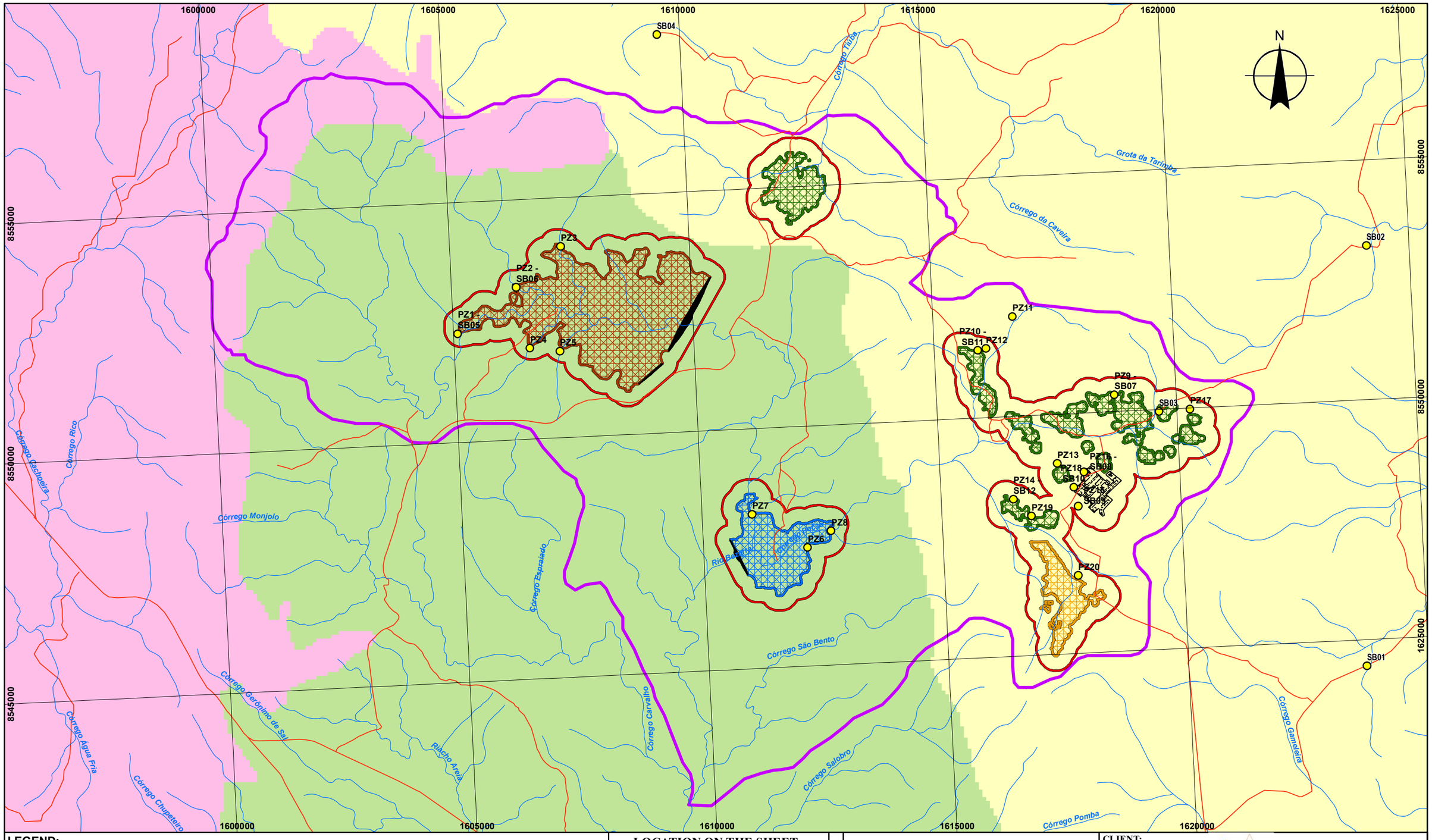
5.2.1.3
Geology

Geologically, the PROJECT ARRAIAS region is located in the State of Tocantins. This State is a megastructure that has developed in Neoproterozoic Orogenic belts within the context of collisional events that culminated in Gondwana Supercontinent amalgamation. In a subdivision on a regional scale, the State of Tocantins has the Brasília Belt as a prominent structure. In the Project's region, the Brasília Belt has granite suites and carbonate and siliciclastic rocks as predominant lithological units.

In the Project's DAI, exposures of granite bedrock attributed to Aurumina Suite, metaconglomerates of Group Araí, pelitic carbonated and phosphated rocks of the Sete Lagoas Formation and pelitic rocks of the Serra de Santa Helena Formation were mapped; the latter two formations belong to Group Bambuí. In the Geomorphological and Geological Maps of **Figures 5.2.1.3.a** it is possible to observe the distribution of these units in the Project's DAA and DAI.

The areas where tailings and catchment dams (DAA) will be implemented are located in exposure areas of Aurumina Suite granite. This unit occurs as a granitoid rock (tonalite), phaneritic to pegmatitic, leucocratic with plagioclase and predominance of quartz, with quartz veins. Some portions have grenades and are milonitized with lineation towards NNE. Soil generated by Aurumina Suite is white, coarse to medium sand, quartzous with pebbles of quartz of angular to subangular veins. Perennial water courses such as the Bezerra River and Poção Creek run largely on tonalite of Aurumina Suite, sometimes changing into waterfalls.

Phosphate deposits are predominantly hosted inside sediments belonging to Group Bambuí, near their limit with rocks of Aurumina Suite granite bedrock. Mining areas (DAA) are located in exposure areas of these lithologies. It is noteworthy that the area planned for the landfill is also located in an area of sediments of Group Bambuí, in the northeast portion of the DAI and north of areas proposed for ore mining.



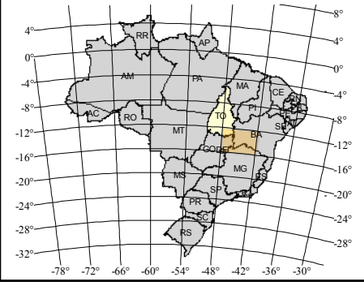
LEGEND:

- Groundwater (SB) and Piezometer (PZ) Locations
- Hydrography
- Roadways
- Industrial Plant
- Dams
- Directly Affected Area (Physical Environment)
- Direct Area of Influence (Physical Environment)
- Water- Catchment Dam
- Tailings Dam (3-20 anos)
- Mining Areas (0-5 anos)
- Mining Areas (>5 anos)

Geology

- Auramine Suite (Granite and Gneisses)
- Araí Group (Quartzites and Silexites)
- Bambuí Group (Limestones, Dolomites, Marls and Siltites)

LOCATION ON THE SHEET



INFORMATION

Source: Information obtained from environmental Impact Assessment - July 2010

Scale:1:75.000

0 0,375 0,75 1,5 2,25 3 3,75 4,5 km

Projection - Universal Transverse de Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

Date: 01/04/2011 | **Fig. JGP: Figure Geological Map.mxd**

CLIENT: ItaFós mineração

PROJECT:

PROJECT ARRAIAS

FIGURE 5.2.1.3.a:

GEOLOGICAL MAP AND GROUNDWATER AND PIEZOMETER LOCATIONS

JGP Consultoria e Participações Ltda.

Related to the Sete Lagoas Formation, two lithofacies occur in the DAI: one composed primarily of siltstones (massive siltstones, laminated siltstones, calciferous siltstones, phosphated siltstones, marls and phosphorites) and another by dolomites. Dolomites have about 80m in thickness, forming isolated hillocks in the topography and escarpments with uniform landscape. Dissolution features are commonly found, such as grooves, limestone pavements, sinkholes, channels and caves in this unit, with well-developed karst relief. Associated with the Serra de Santa Helena Formation, siltstones silicified to massive silexites occur in yellow to white color, sometimes pink, composing a series of elongated hills towards W-E and over the Sete Lagoas Formation.

Paleontological surveys were not carried out in the study area; however, stromatolites in limestone rock and the existence of caves with possible Pleistocene mammal fossils, make it necessary to carry out paleontological studies in the area with occurrence of the Bambuí Group. These studies will be carried out as part of the Supplementary Baseline Programs.

In terms of seismicity, the Project area is located northeast of the Porangatuba seismogenic zone according to Mioto (1993), and in the study area and surrounding areas there are only two recorded small-intensity events (less than 3 on the Richter Scale).

Mineralization

The various small occurrences of phosphorites in the basal of the Sete Lagoas Formation on the border between the states of Tocantins and Goiás were discovered by METAGO (Metais de Goiás) research in the 70's (METAGO, 1979 *apud* ALVARENGA *et al*., 2007). Phosphorites form lenses reaching a few tens of meters long and about two meters thick, inside siltstones and shales, and fluorapatite is the main mineral ore. These occurrences have been affected by the lateritic change that caused the formation of a friable earthy brown ore, with local development of siliceous crust containing wavellite, another mineral phosphate ore (ALVARENGA *et al*., 2007).

Phosphorites found are (MONTEIRO, 2009):

- Stratified primary phosphorites – thin layered or laminated phospholutites and phospharenites in purple, yellow and beige colors, with P_2O_5 contents from 24 up to 32%;
- Brecciated phosphorite - formed from the reworking of stratified primary phosphorite, with which it is interdigitated. Centrimetric to decimetric clasts and intraclasts are distinguished, subangular to subrounded phosphorites, yellow and purple siltstones, quartz and silexites immersed in colofanite matrix, reaching contents of 34% of P_2O_5;
- Pedogenic phosphorites - phosphorites in advanced stages of laterization over brecciated and stratified phosphorites, with contents of about 27% of P_2O_5;
- Phosphated siltstone - corresponds to a larger volume of phosphate ores, bordering phosphorites with variable contents of P_2O_5.

Itafos has delimited the target areas for its mineral research as being the following:: Coité, Cana Brava, Mateus, Juscelino, São Bento and Gaúcho. These areas have been prospected for phosphate and have being identified as having the mineral of interest; thus the establishment of mines in these areas is expected, according to DAA delimitation (**Figure 2.6.1.a**).

5.2.1.4
Speleology

For speleological studies, initially bibliographical surveys were conducted and data from the sites of Sociedade Brasileira de Espeleologia – SBE (http://www.sbe.com.br) and Redespeleo Brasil (http://www.redespeleo.org.br) was gathered, which have a record of caves in Brazil. CECAV (Centro Nacional de Estudos, Proteção e Manejo de Cavernas) database was also consulted. On the map of Cave Occurrence Potential available on CECAV site (http:// www4.icmbio.gov.br/cecav/index.php? id_menu = 230), part of the area, especially where Sete Lagoas Formation lithologies of Group Bambuí are distributed, has a very high occurrence potential for natural cavities (100 to 80%). This DAI portion is part of Bambuí Speleological Province that covers the largest set of limestone occurrences favorable to the presence of caves in Brazil (ROLDAN et al., 2004).

Field surveys of speleology were carried out in two stages: between February 18 and 22 and June 2 and 7, 2010. Field work of biospeleology of invertebrates was carried out in the first field campaign between October 3 to 7, 2010, in the dry season, and the second campaign between November 15 and 20, 2010, in the rainy season. The campaign of chiropterans was carried out between October 4 and 7, 2010 (dry season campaign), and between November 14 and 18, 2010 (wet season campaign).

During the field work, the satellite image World view-2 with 50 cm resolution, created on March 28, 2010, was used, which made it possible to locate important features characteristic of karst relief, directing field work to these points and allowing the tracing of a pathway. Cavities with horizontal projections greater than five meters were registered and their topography recorded using the rapid method with compass, clinometer and measuring tape. Interviews with local people with regional knowledge were also carried out to identify potential sites with cavities.

The study area considered is equivalent to a surrounding region of 250 m from the mining and industrial complex areas, since the other directly affected areas, including dam areas, are not located in potentially karst lands composed of lithotypes of Group Bambuí.

In the areas of distribution of Group Bambuí rocks, part of the relief is karst (Group Bambuí), with features representative of sinkholes, limestone pavements, dissolution grooves, pinnacles, towers and stone arches and cavities.

In the surrounding region of 250 m from the planned mining areas, 12 cavities with horizontal projection greater than or equal to 5m have been identified, as shown in **Table 5.2.1.4.a**.

Table 5.2.1.4.a
Location of Natural Cavities found around 250m from the DAA

Cavities	Coordinates (UTM)	
POINT 002	310,670	8,569,864
POINT 003	310,691	8,569,943
POINT 013	308,889	8,573,317
POINT 014	308,841	8,573,353
POINT 016	308,813	8,573,435
POINT 017	308,811	8,573,431
POINT 020	308,724	8,573,347
POINT 041	309,311	8,570,219
POINT 044	309,726	8,570,219
POINT 050	310,273	8,570,890
POINT 051	310,325	8,570,887
POINT GEO 08	310,843	8,568,299

The twelve (12) cavities identified are located outside the areas earmarked for mining; however, their areas of influence will possibly be affected. It is noteworthy that the area of influence of each cavity corresponds to the "area that includes biotic and abiotic elements, surface or underground, necessary to maintain the ecological balance and physical integrity of the cave environment", according to subparagraph IV of article 2 of CONAMA Resolution no. 347 of September 10, 2004.

Also in accordance with this resolution, the area of influence on speleological patrimony will be defined by the competent environmental authority, or until the expected is done, "it will be the horizontal projection of the cave plus a surrounding area of 250m, in form of convex polygon" (paragraph 3, article 4).

Finally, studies were conducted to define the relevance classification of the twelve (12) natural cavities located in the study area, whose attributes defined for classification were those set forth in Normative Instruction No. 2 of the Ministry of Environment of 20 August 20, 2009. This norm establishes criteria in order to classify the relevance degree of caves in maximum, high, medium or low, by utilizing 34 atributes for such classification.

Among the twelve (12) caves in this study, eleven (11) were classified as highly relevant mainly due to presence of troglomorphic species, species with important ecological functions and new taxons. Since the caves themselves are located outside the DAA, they are not expected to be directly affected. However, due to possible intersections between caves' areas of influence and the project's DAA and to the caves being located within the Project's DAI, the caves will require monitoring activities to ensure the protection of speleological heritage.
The possible occurrence of natural caves with no surface openings makes it necessary to carry out geophysical studies to detect these structures and other underground geological-geotechnical features of the karstic landform. These surveys will be performed as part of the Supplementary Baseline Programs and will be carried out in the implementation area of the industrial facility of the future mine.

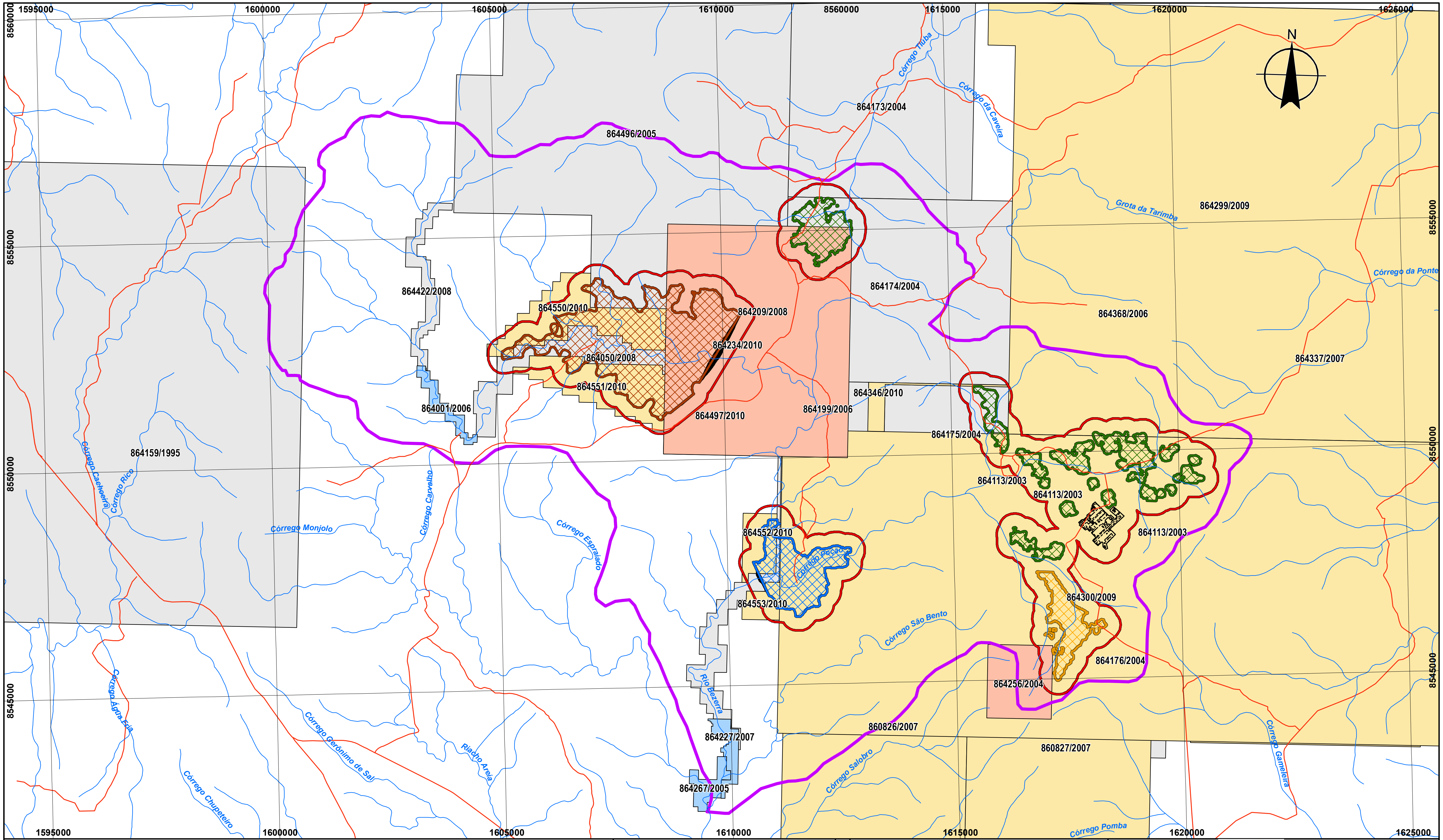
5.2.1.5
Mineral Resources

In addition to phosphate, ore other mineral substances are present in the municipality of Arraias. For example industrial non-metallic minerals, inputs for agriculture, minerals for immediate use in civil construction and precious stones. This becomes evident as mining applications to the National Department of Mineral Production (DNPM, in Portuguese) in the States of Tocantins and Goiás, highlight gold and phosphate research and extraction, including the eastern part of Arraias municipality.

From research carried out with DNPM databases, it was possible to identify 21 active mining applications in the Project´s DAI (situation as of April 1, 2011), seven (7) were in the research authorization phase, eleven (11) in the research phase, two (02) are available and only one (01) in the mining request process.

The final one corresponds to a mining application on behalf of Itafós for phosphate exploration. Also on behalf of Itafós there are eight more (08) mining applications in the research authorization phase. All nine (09) of these mining applications on behalf of the Project Company are located in the PROJECT ARRAIAS DAA, as shown in **Figure 5.2.1.5.a**. The Exploration Leases were originally issued for gold and later on the Project Company must inform the DNPM about occurrences of phosphate.

The final location for the tailings and water catchment dams interfere with polygonal areas of mining applications not pertaining to the Project Company at the time of consulting DNPM's database, and all of these applications were in research authorization phase, request for research or available, so far with no evidence of existence of minerals of interest.



LEGEND:

- Hydrography
- Roadways
- Water- Catchment Dam
- Tailings Dam (3-20 anos)
- Mining Areas (0-5 anos)
- Mining Areas (>5 anos)

Mineral Resources

Phase

- Authorization for Research
- Availability
- Licensing
- Mining Request
- Research Request

LOCATION ON THE SHEET

INFORMATION

Source: Information obtained from environmental Impact Assessment - July 2010

Scale: 1:80.000

0 0,375 0,75 1,5 2,25 3 3,75 4,5 km

Projection - Universal Transverse Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

Date: 01/04/2011 | Fig. JGP: Figure Mineral Resources .mxd

CLIENT:

ItaFós mineração

PROJECT:

PROJECT ARRAIAS

FIGURE 5.2.1.5.a:

MINERAL RESOURCES MAP

JGP Consultoria e Participações Ltda.

With respect to winds, data obtained at the Taguatinga station indicates the occurrence of weak to moderate winds, with maximum speed of 5m/s (18 km/h), predominantly from the northeast. At the Paranã station light winds with maximum speed of 1.3 m/s (5 km/h) were observed, predominantly from the southeast. Data obtained at Taguatinga and Paranã stations refers to 2009.

In February and June 2010, in the same air quality monitoring points (Section 5.2.1.2), wind speed and direction were measured in the surrounding areas of the future industrial complex and mining areas. In February, the predominant wind direction was SSW and SW, and wind speed varied from 0.5 and 1.1 km/h. Wind directions observed in June were E and SE, with predominance of the former and wind speed reaching 0.5 to 5.3 km/h.

5.2.1.6
Soils

Project Radam Brasil (1982), at a scale of 1:1,000,000, recorded classes of Latosol, Cambisols, Litholic Neosols and Plinthosols in the Project area, the latter being predominant.

For execution of detailed pedological mapping for the Project DAI 1:50000 scale map was prepared. First, a pedological sketch was built using the existing pedological, geological and geomorphological basis. Likewise, information about landforms and drainage system were essential for the establishment of soil classes for the study area. The detailed geomorphological map was used as a base document for the pedological mapping. High resolution satellite imagery was also used in April 2010 on a digital elevation model developed from DSG official base, 1:50000 scale, in addition to altimetric data of the ASTER/NASA system with a spatial resolution of 30m and topographic profiles.

In possession of the sketch, field work was carried out to check soil classes mapped with evidence by means of boreholes, checking of road and ravine cuts, mining open areas and stretches exposed by drainage.

The verification of soil classes complied with the procedures described in the Technical Handbook of Pedology (IBGE, 2007), Field Soil Description and Collection Handbook (SANTOS *et al*., 2005), Handbook of Soil Classification in Brazil (PRADO, 1996). The classification followed the guidelines expressed in the Brazilian Soil Classification System (SANTOS *et al*., 2006). The description of field soil with the collection of samples included the record of its characteristics through an examination of its profile, characterizing the horizons observed.

Given the characteristics observed in the field and obtained in cartographic materials consulted, five classes of soil were identified for the study area, classified up to the 2nd category level (Suborder), divided into Petric Plinthosols (FF), Haplic Cambisols (CX), Entisols (RL), Quartzarenic Neosols (RQ) Red Lathasols (LV). It is noteworthy that alluvial soils in the area have low expression occurring in a restricted manner on the banks of some rivers, such as Bezerra, and classified according to the Brazilian Soil Classification System of EMBRAPA as Quartzarenic Neosols.

In the area drained by the Bezerra River, especially in its upper course inserted into the granite massif of Araumina Suite in the region of Arraias, its hydraulic power has produced a dissected model ranging from wavy to smooth wavy with domain of Plinthosol and Cambisol soil classes with presence of concentration of ferruginous concretions in surface horizons (epiconcretionary) . In areas dominated by Group Bambuí geology, the relief is relatively undulating with uniform low mountains (karst) with a predominance of alic epiconcretionary Cambisol, Neosol and Red Lathasol soils.

5.2.1.7
Geomorphology

Regional Geomorphology

The survey carried out by Radam Brazil Project (1982) subdivided the Brasília Sheet (SD-23) into several domains, regions and geomorphological areas. The Project region is in the Tocantins Depression Domain. Landforms that occur in this domain resulted from the razing by erosion, and are vast pediplaned area surrounded by interplateau and peripheral planning surfaces, some karstified. Landforms in this domain are primarily Aurumina Suite granite-gneiss rocks, and Group Araí quartzites, which generally support the region most prominent reliefs.

The most lowered areas are settled on Group Bambuí bedrock composed of interbedded siltstone/phyllites and limestones, which in some stretches result in karstified land feature with sinkholes, uvalas, caves, limestone pavement and other forms that compose this type of resultant.

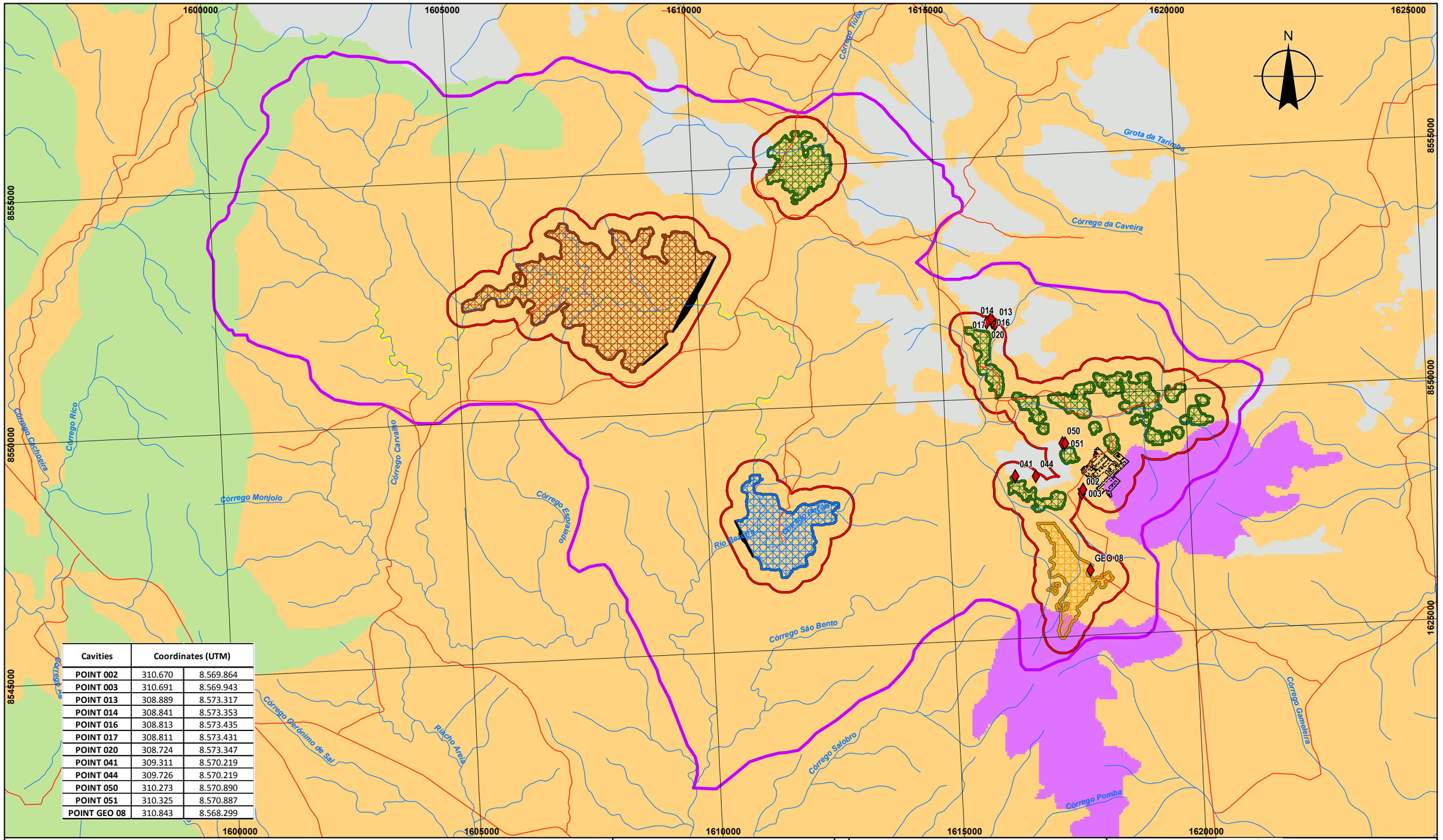
Local Geomorphology

Heterogeneity of morphology found in the compartment of Tocantins Depression, or even individualized in large pediplaned areas that compose it, form a set of morphologies or resultant types grouped into landforms with very similar geometry due to its common genesis and generalization of active morphogenetic processes, resulting in the recurrence of superficial correlative materials.

In the Project´s DAI responses to the action of geomorphological processes in substrates generated forms linked to three morphogenetic types, which were classified as follows:

- Forms related to denudational processes, called *Resultant Degradation and Planning*.
- Forms related to accumulation processes called *Resultant River*.
- Forms related to dissolution processes called *Resultant Karst Dissolution*.

From the recognition of major resultant landforms a detailed geomorphological map was prepared on a scale of 1: 50000. This map complied with field procedures described in Tricart (1965) with photo interpretation and subsequent observations, collections and analyses in order to characterize landforms. By mapping 5 (five) geomorphological units in the DAI and its near surroundings were identified, as shown in **Figure 5.2.1.7.a** Map (this figure corresponds to drawing no. 988.0.2.1 .- EIA - 06 of the EIA without containment dam), which are: Restricted River Plains, Karstic Low Mountains, Residual Mountains, Residual Low Mountains and Degraded Pediplane.



Cavities	Coordinates (UTM)	
POINT 002	310.670	8.569.864
POINT 003	310.691	8.569.943
POINT 013	308.889	8.573.317
POINT 014	308.841	8.573.353
POINT 016	308.813	8.573.435
POINT 017	308.811	8.573.431
POINT 020	308.724	8.573.347
POINT 041	309.311	8.570.219
POINT 044	309.726	8.570.219
POINT 050	310.273	8.570.890
POINT 051	310.325	8.570.887
POINT GEO 08	310.843	8.568.299

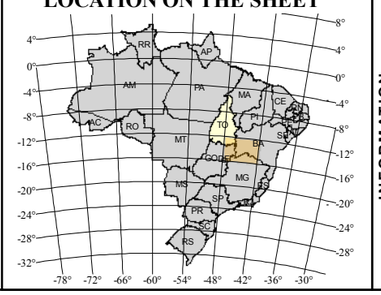
LEGEND:

- Natural Underground Cavities
- Hydrography
- Roadways
- Industrial Plant
- Dams
- Directly Affected Area (Physical Environment)
- Direct Area of Influence (Physical Environment)
- Water- Catchment Dam
- Tailings Dam (3-20 anos)
- Mining Areas (0-5 anos)
- Mining Areas (>5 anos)

LANDFORM TYPES

- Karstic Low Mountains
- Residual Low Mountains
- Degraded Pediplane
- Restricted Fluvial Plains
- Residual Mountain Ridges

LOCATION ON THE SHEET



INFORMATION

Source: Information obtained from environmental Impact Assessment - July 2010

Scale: 1:75.000

0 0,375 0,75 1,5 2,25 3 3,75 4,5 km

Projection - Universal Transverse de Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

Date: 01/04/2011 | **Fig. JGP: Figure Geomorphological.mxd**

CLIENT: ItaFós mineração

PROJECT:

PROJECT ARRAIAS

FIGURE 5.2.1.7.a:

GEOMORPHOLOGICAL MAP AND CAVITIES

JGP Consultoria e Participações Ltda.

Environmental Fragility

To generate the synthesis map of environmental fragility, the interpolation of five thematic maps was carried out: soil use and occupation, pedology (soils), clinographic (declivity), geomorphological (relief) and geological maps (lithology), all on 1:50.000 detailed scale. The results obtained were presented on an Environmental Fragility Map, where five levels of potential fragility were classified: very low, low, medium, high and very high. These fragility levels indicate the level of vulnerability to processes caused by diffuse and concentrated rain water surface runoff, as defined by Ross (1994).

After constructing the synthesis map in GIS environment, the comparison with the geomorphological map showing the mapping of morphological features evidencing some kind of process related to erosions, siltation, consolidations, among others, and morphologies that have higher propensities to trigger processes related to surface dynamics.

These features were removed from the detailed geomorphological map, and in complementary way helped in the fragility interpretations. Linear symbols plotted on the synthesis map were used. To complement the mapping a field study to verify the occurrence of erosion features of siltation was performed, as well as those linked to other processes that dominate the area morphodynamics.

Data analyses lead to the conclusion that the class with higher occurrence is the one of medium fragility, amounting to approximately 52.17% of the area, followed by those of low fragility with 43.08%. These areas are occupied by Tocantins pediplane, both in Suite Aurumina drained by the Bezerra River and in plain areas on the valley bottom and stretches with siltstones of Group Bambuí. The main factor for this classification was mainly the low declivity coupled with factors related to geology, soil type and land use and occupation.

The areas showing high fragility with 4.72% of the mapped area are concentrated in residual reliefs located in the western portion of the map where Arraias and Chapada dos Negros Mountains are settled. In the eastern portion where there are karst rocks high fragilities occur as well. In areas totaling 21.92 ha (0.04%) too high fragilities occur, which are intercalated with high fragility areas, especially in some deforested parts.

The area encompassed by this study has a predominantly medium and low degree of fragility. High fragilities identified are closely linked to areas with steeper slopes and karst lands that have inherent fragilities. The class of very low fragility was not mapped for the area.

5.2.1.8
Hydrogeology

The underground hydric regime is subject to the existing type of rock. And the rock's structural geological framework, with its features of both deformation and metamorphism, conditions hydraulic characteristics.

Aquifer Systems

The main aquifer systems occurring within the DAI of PROJECT ARRAIAS are:

- **Aurumina Suite Crystalline Aquifer System**: in the area it consists of locally milonitized granites and tonalites coincident with the coverage area in distribution areas of the Aurumina Suite lithostratigraphic unit, especially in the DAI central portion and in the construction area of water catchment and tailings dams.

- **Bambuí Karstic Aquifer System**: mainly represented in the DAI by the Sete Lagoas Formation of Group Bambuí, consisting of marls, siltstones, laminated to banded limestones, clayey limestones and dolomites. It occurs eastwards of the Project´s DAI where siltstones outcrop in lower and flat regions, while dolomites form isolated hillocks and mountains.

  The aquifer generated over Group Bambuí is karstic with large areas without surface water currents, with occurrence of more or less large depressions, with underground drainage, presence of cavities (channels, fracturing and caves) through which groundwater currents circulate. Physical and hydrodynamic properties of this type of aquifer are varied, showing small amount of surface runoff, complex groundwater water circulation, both in saturated zones and above the aquifer potentiometric surface, very quick infiltration of rain and other surface waters, and anomalies in water flow direction in relation to regional potentiometric gradient.

  The area shows features typical of karst systems surface, such as sinkholes and caves, which are the system's recharge areas. Sinkholes as well as caves and channels capture water from a micro-watershed to fill the aquifer.

  Water levels obtained in 26 survey holes that crossed siltstone and found water in the karst aquifer indicate minimum depths of 34 me maximum of 50m. In SB03 groundwater well used for collecting samples for quality analysis, which is located in the karstic aquifer area of the DAI, a water level of 100 m was obtained.

- **Phreatic Aquifer System**: This system constitutes intergranular type, continuous and free aquifers of large lateral extension, possibly restricted to times of heavier rainfall and with high hydrogeological importance, especially regarding refilling aspects of deeper reservoirs on the karst aquifer, and with regulation of surface drainage flows on fractured aquifers;

  This shallow aquifer system is represented by varied autochthonous soils with thickness from 2 until about 5 meters, which basically work as a filtering means for water percolation to other deeper aquifers due to the scarce network of perennial superficial drainages.

Aquifer Vulnerability Appraisal

The analysis of the natural vulnerability of the aquifers was obtained by a methodology proposed by Foster and Hirata (1993). This appraisal, based on pre-existing data, takes into account three basic parameters, and for each one of these parameters pre-established values are set in the model, varying in a scale from 0 to 1:

- (a) Groundwater occurrence, that is the hydraulic confinement degree (unconfined = 1.0, unconfined covered = 0.5, semi-confined = 0.4, confined = 0.2 and none = 0);
- (b) Overall litology of aquiperm (vadose or unsaturated zone of aquifers) or aquitard (confining beds overlying a saturated aquifers) (for example, residual soils = 0.4, alluvial silts/mudstones = 0.5, siltstones/igneous rocks = 0.6, sandstones = 0.7, limestones = 0.9, consolidated rocks = 1.0);
- (c) Depth to groundwater (> 100m = 0.4, 50-100m = 0.5, 20-50m = 0.6, 10-20m = 0.7, 5-10m = 0.8, 2-5m = 0.9 and < 2m = 1.0)

Taking into account values given to these attributes, the result is the natural vulnerability ratio of aquifers by multiplication. This leads to rating of the aquifer into Natural Vulnerability Classes, which are determined by how the aquifer is adversely affected by a contaminating surface load: None = 0, Negligble = 0-0.1, Low = 0.1-0.3, Moderate = 0.3-0.5, High = 0.5-0.7 and Extreme = > 0.7.

The domains with extreme vulnerability correspond basically to the entire area occupied by the Sete Lagoas Formation (Grupo Bambuí) due to the prevailing aquifer environments with high transmissivity and hydraulic conductivity and because the site is occupied by surcharge zones. Among the aquifer systems with moderate vulnerability are those embedded in the Araí and Serra de Santa Helena Formations that have limited occurrences in the Project´s DAI. In Aurumina Suite, areas of occurrence of granitic aquifer with greater distribution in the DAI, the vulnerability to contamination was low.

In this respect it is important to note that the risk of aquifer contamination is marginal.

Ground Water Quality

One well for collection and analysis of groundwater has been identified in the Project's DAI (Point SB 03 – **Figure 5.2.1.3.a)**. Outside of the DAI, but in its vicinity, another three wells for water extraction and use were found. Thus, in order to characterize groundwater quality in the Project´s area of influence samples were collected from these wells **(**Points SB 01 to 03 – **Figure 5.2.1.3.a)**.

After collection, all duly preserved samples were sent to Laboratório de Microbiologia Ambiental da Universidade Federal do Tocantins [Environmental Microbiology Laboratory]. In each of the samples the following parameters were determined: Calcium (mg/L), Magnesium (mg/L), Sulfate (mg/L), Chloride (mg/L), Sodium (mg/L), Potassium (mg/L), Iron (mg/L), Manganese (mg/L), Total Phosphorus (mg/L), Nitrogen (mg/L), Total Dissolved Solids (mg/L), Color (Pt/L) - Suspended Solids (mg/L), Turbidity (NTU) and Fecal Coliforms (MPN/100 mL.

As a starting point to be emphasized, the influence of local bedrock on the chemical characteristics of water bodies assessed is highlighted. In this context it is worth mentioning that the highest concentrations of bicarbonate, calcium, magnesium and sulfate from water sources sampled are due to the lithological characteristics of Group Bambuí, while the highest concentrations of sodium and potassium can be attributed to the weathering of rocks in the Goiás complex (Suite Aurumina).

Regarding groundwater sampling points, greatest concern is with regards to high concentrations of fecal coliforms identified at all three collection points. As already mentioned, considering that the samples were collected in wells or water holes located near the residence of the rural property, it is possible that the use of these properties is responsible for fecal contamination of water analyzed.

Given this diagnosis, PROJECT ARRAIAS will define and implement an environmental program during construction and operation comprising monitoring of water quality of the collection points sampled, so that during a longer period of time an improved understanding of watershed ecology in the region is allowed, as well as the identification of possible changes in water quality of these sources during the Project´s operation and construction.

The Bambuí aquifer classification as extremely vulnerable to contamination indicates a need for monitoring the quality of its waters especially near the industrial unit and of the wells for drinking water. In addition, appropriate measures will be taken to minimize risks of accidents with hazardous chemicals and effluents, as well as it will develop and implement contingency plans in case of occurrences of incidents involving hazardous chemicals, as indicated in **Section 7.3.**

Thus, an extra 8 points will be included in the monitoring phase sampling grid to assess groundwater quality (Points SB 5 up to SB 12). Two of those will be located near the tailings dam area, one near the landfill and the other 5 points will be located near the industrial complex and mining area. **Table 5.2.1.8.a** and **Figure 5.2.1.3.a** show descriptions of the locations of points studied in the ESIA and points proposed for the monitoring phase.

Twelve water level monitoring points will be set up along the mine and industrial areas and 8 more points will be distributed along the tailings and water catchment dams. The distribution of these points (PZs) can be observed on the Map in **Figure 5.2.1.3.a.**

Table 5.2.1.8.a
Description of groundwater quality sampling points (Points SB 01 to 04 analyzed during the EIA and Points SB 06 to 12 included for the monitoring phase)

Point	Description	Coordinates (UTM)	
		E	N
SB01	Shallow well (cistern)	316679	8566700
SB02	Cacimba (outcrop)	316665	8575333
SB03	Installed well	312407	8571926
SB04	Deep tubular well	302083	8579669
SB05	Bank of the Tailings dam	298025	8573566
SB06	Bank of the Tailings dam	299226	8574526
SB07	North of the Juscelino area	311525	8572318
SB08	Production Area	310906	8570732
SB09	Production Area	310780	8570030
SB10	Production Area	310697	8570419
SB11	North of the Coité area	308722	8573227
SB12	North of the São Bento area	309449	8570169

The analysis of all new points shall be incorporated in the monitoring phase in both the installation and operation phases.

Finally, in light of new data generated either by the piezometric monitoring or that planned to be started with the Project´s construction, it should be emphasized that the possibility of inserting new collection points can not be discarded, as well as adjustments in the location of some of these points aiming at improving the sampling network.

5.2.1.9
Surface Hydrology and Water Quality

According to the National Water Agency (ANA, in Portuguese) the municipality of Arraias is inserted in the Araguaia-Tocantins classification for large watersheds in Brazil.

The Project´s study areas are characterized by the presence of two major water bodies in the region of the municipality of Arraias, the Bezerra River and Poção Creek. Both are inserted into the Paranã River subwatershed. There are also other water bodies in the Project´s areas of influence such as the Cachoeira Creek, Gameleira Creek, Tiúba Creek, Bom Sucesso Creek, among others with perennial characteristics and others with intermittent characteristics. All the rivers mentioned are under the influence of the Palma River subwatershed, a tributary of the Paranã River as well.

Therefore, the Project´s DAI is drained by subwatersheds of rivers Palma and Bezerra, inserted into the Paranã River basin, which in turn is a tributary of the Tocantins River.

The main water bodies located in the Project´s DAI are the Bezerra River and its tributary on the left bank, and Poção Creek, where tailings and water catchment dams will be constructed respectively, in addition to mining areas in the latter. Extraction fronts are also planned in the drainage area of the Tiúba Creek, a tributary of the Palmas River located northwards of PROJECT ARRAIAS DAI.

Water courses seen as perennial were the Poção Creek and Bezerra River, which have their courses on Aurumina Suite and Araí Formation rocks. Other tributaries of the Bezerra River and Poção Creek having courses on granites are seen as perennial drainages, while most water courses running on limestones and siltstones have intermittent characteristics.

Surface Water Quality

For the development of this study two field campaigns were performed; the first in March 2010 (rainy season) and the second in June 2010 (dry season). The sampling frequency used (dry and rainy seasons) allowed the identification of effects provided by the seasonal variation in concentrations of the parameters determined in physicochemical and bacteriological analyses.

For the sampling of surface water resources, the major micro basins directly affected were included, with emphasis on the Bezerra River and Poção Creek. Inside the Study Area, sampling points in the Tiúba Creek micro basin were also selected for including potential areas of exploration.

For the sampling of surface water resources seven collection points were defined, points 05 to 12, whose location description is shown in **Table 5.2.1.9.a**. Besides these points, five new ones will be included in the sampling grid for the monitoring phase (Points 13 to 16), distributed between the vicinity of the tailings and water catchment dams and Poção and Tiúba Creeks.

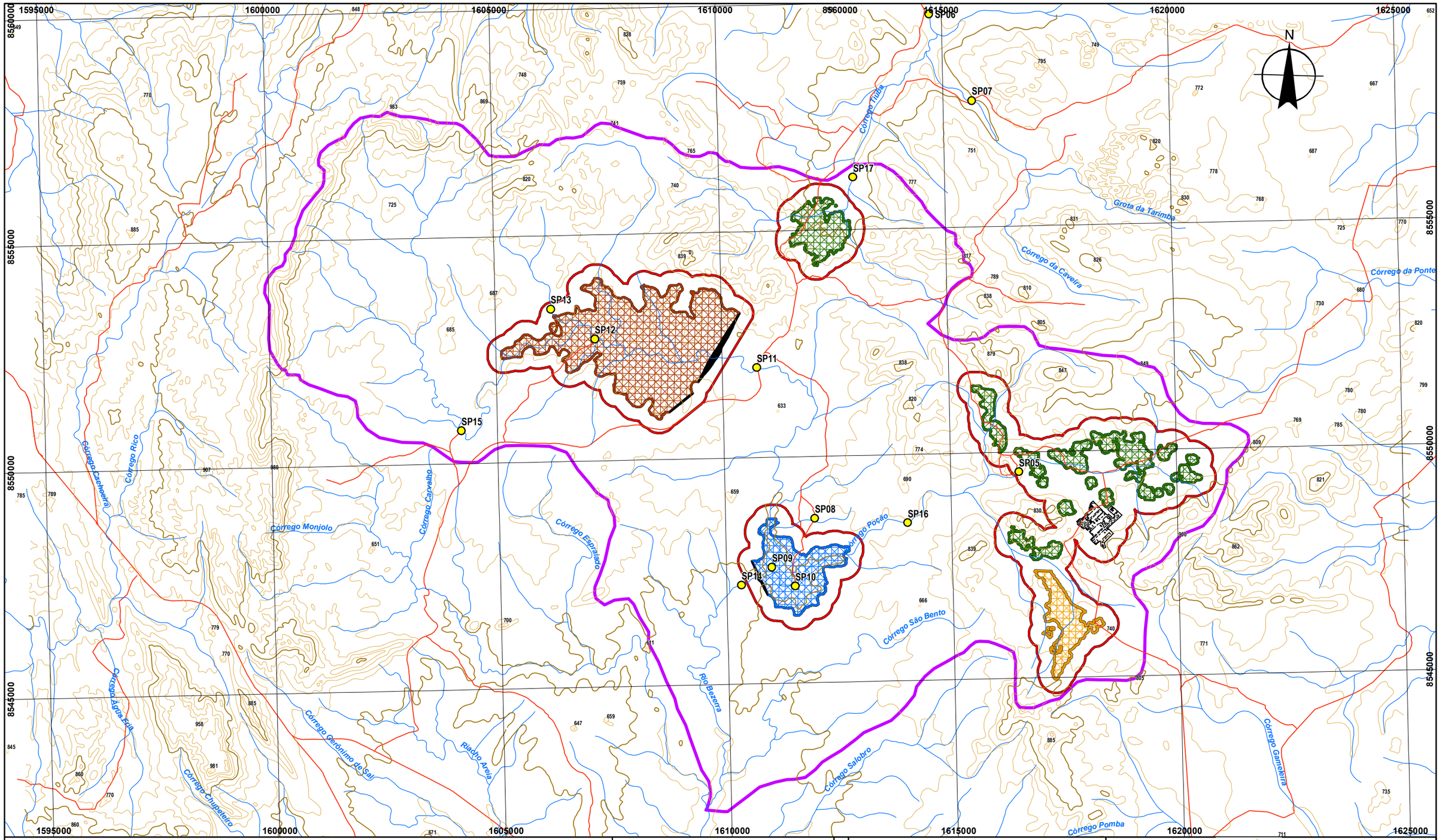
To evaluate the effects of tributaries that will be affected by the flooding of the tailings dam, points 13 and 15 where strategically located upstream upstream of the area flooded. These points will enable a better understanding of the tailings dam effects on surface water quality. Still with the aim of evaluating the Tiúba Creek water quality and possible consequences of mining activities on its quality, a point just downstream of the areas earmarked for mining will be proposed, in the DAI segment (point SP17).

Analysis of all new points will be incorporated into the monitoring stage during the construction and operations phases.

Table 5.2.1.9.a
Description of surface water quality sampling points (Points SP 05 and 12 analyzed during the EIA and Points SP 13 and 17 included for the monitoring phase)

Point	Description	Coordinates (UTM)	
		E	N
Point 05 (SP 05)	Downstream of the mine área – Poção Creek	309302	8571338
Point 06 (SP 06)	Tiúba Creek	307173	8581268
Point 07 (SP 07)	Tiúba Creek	307129	8579442
Point 08 (SP 08)	Tributary – Catchment Dam	304941	8570249
Point 09 (SP 09)	Catchment Dam	304027	8569041
Point 10 (SP 10)	Catchment Dam - upstream	305871	8569619
Point 11 (SP 11)	Tailings Dam - Downstream	303536	8573466
Point 12 (SP 12)	Tailings Dam	301273	8573712
Point 13 (SP 13)	Tributary - Tailings Dam	299064	8574670
Point 14 (SP 14)	Catchment Dam - Downstream	303378	8568766
Point 15 (SP 15)	Tailings Dam - Upstream	297189	8571968
Point 16 (SP 16)	Containment Dike	306962	870218
Point 17 (SP17)	Tiúba Creek – at the DAI boundary	305570	8577715

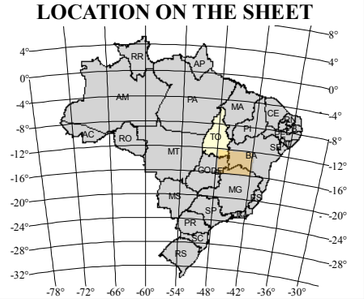
The map with the locations of surface water sampling points is shown in **Figure 5.2.1.9.a**.



LEGEND:

- Elevation Points
- Proposed Monitoring Points
- Master Curves
- Intermediate Curves
- Hydrography
- Roadways
- Industrial Plant
- Dams
- Directly Affected Area (Physical Environment)
- Direct Area of Influence (Physical Environment)
- Water- Catchment Dam
- Tailings Dam (3-20 anos)
- Mining Areas (0-5 anos)
- Mining Areas (>5 anos)

LOCATION ON THE SHEET



INFORMATION

Source: Information obtained from environmental Impact Assessment - July 2010

Scale: 1:80.000

0 0,375 0,75 1,5 2,25 3 3,75 4,5 km

Projection - Universal Transverse Mercator - UTM
Geodesic Reference System: South American Datum - SAD 69

Date: 01/04/2011 | **Fig. JGP: Figure Surface Water.mxd**

CLIENT: ItaFós mineração

PROJECT:

PROJECT ARRAIAS

FIGURE 5.2.1.9.a:

LOCATION OF SURFACE WATER QUALITY POINTS

JGP Consultoria e Participações Ltda.

Parameters assessed

To assess surface water quality 30 physicochemical and bacteriological parameters were analyzed. The analyses were conducted by the Laboratory of Environmental Microbiology of the Federal University of Tocantins. For each of the samples, the following parameters were analized: water temperature (°C), turbidity (NTU), pH, electrical conductivity (μS/cm), dissolved oxygen (mg/L), BOD (Biochemical oxygen demand) (mg/L), Calcium (mg/L), Magnesium (mg/L), Carbonate and bicarbonate (mg/L) Sulfate (mg/L), Chloride (mg/L), Sodium (mg/L), Potassium (mg/L) Iron (mg/L), Manganese (mg/L), Total Phosphorus (mg/L), and total and organic nitrogen (mg/L), ammonia (mg/L), nitrite (mg/L), nitrate (mg/L), Total Dissolved Solids (mg/L), Color (Pt/L) - Suspended Solids - total, fixed and organic matter (mg/L), total and fecal coliforms (MPN/100ml) and determination of Water Quality Index.

According to CONAMA (National Environment Council, acronym in Portuguese) Resolution 357/05, which determines Brazilian water quality Standards, the samples collected throughout the study indicate a generally good surface water quality, with most results within the limits defined by the Resolution.

To complement water quality analysis, calculations of the "Trophic State Index" will be included during the monitoring phase for all collection points. This parameter indicates the trophic level of the environment, which in turns helps identify the risk of eutrophication of the water systems in different areas of the Bezerra River watershed.

Results

The results analyzed in order to determine water quality, classified as Class 2 according to CONAMA Resolution 357/05, in general showed results consistent with the limits set by the mentioned resolution. Some exceptions were observed for Dissolved Oxygen (Point 8, dry period), BOD, pH (Point 10, rainy season), Iron (Point 11, rainy season), Manganese (Points 5 and 8 in the rainy season, Point 8 in the dry season), Total phosphorus (points 6, 7 and 8 in the dry season) and Fecal coliforms (Point 6 in the rainy season; Points 7 and 11 in the dry season).

It can be concluded that such variations (above the recommended standard) were largely derived from geochemical characteristics or particularities of the region. Specifically for the results of fecal coliforms no urban center was recorded in the vicinity of points 6, 7 and 11, which excludes the possibility of sewage release into the water body. However, rural properties in the area of influence of the sampling points may possibly have contributed to higher concentrations of this parameter.

Considering the scenario observed, diffuse or specific sources of pollution that may significantly impair water quality of surface springs of interest in this study and which might represent an impediment to the construction of dams in the Project area were not identified during the present survey. Eutrophication and other processes potentially affecting water quality in the reservoir will be assessed through appropriate modeling techniques (CE-Qual-W2). This will contemplate water quality impacts downstream as well, and will be concluded before dam construction, as indicated in **Section 6.3**.

Finally, in light of new data generated either by the planned modeling mentioned in **Section 6.3** or by the monitoring planned to start with the project construction, it should be emphasized that the possibility of inserting new collection points and of making adjustments in the location of some of these points aiming at improving the sampling network cannot be discarded.

To ensure that the proposed ecological flow rate of 30% is sufficient for the maintenance of aquatic fauna during the monitoring phase flow studies will be carried out in water bodies before the dam construction, as indicated in **Section 5.2.5**. These data will help the detailed study of ecological flows for the Bezerra River, which will be completed before the dam construction.