Yaoure Gold Project, Côte d'Ivoire

Environmental and Social Impact Assessment

Appendix 7
Baseline of Soils and Land Capability




Submitted to

Amara Mining Côte d'Ivoire SARL

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EXECUTIVE SUMMARY

Introduction / Background

Amara Mining PLC (Amara) is a public limited company trading on the London Stock Exchange (AIM market), with its head offices in London, UK. Amara is seeking to develop its 100 percent owned Yaoure Project in the Department of Bouafle in the Ivory Coast, or Côte d'Ivoire. The Yaoure Project is presently in the prefeasibility stage of development.

As part of its pre-feasibility work, Amara is carrying out an Environmental and Social Impact Assessment (ESIA) process, in compliance with the Ivorian Mining Code (Law No. 2014-138 of 24 March 2014 on the Mining Code), and the Environmental Code (Law No. 96-766 of 3 October 1996 on the Environment Code and applicable Decrees, as well as the International Finance Corporation Performance Standards on Environmental and Social Sustainability, 2012 (IFC PS). Amara intends to complete an ESIA during the pre-feasibility stage.

As part of the ESIA process, these specialist soils and land capability baseline investigations and studies have been prepared in line with the Mining and Environmental Laws and Policies that pertain in Côte d'Ivoire, with the IFC Performance Standards (PS), 2012 as a guideline in best practice.

The ESIA process in Côte d'Ivoire is guided by the Environmental Code. In terms of the Code, the first step in the ESIA process is to submit a Technical Report to ANDE which contains a description of the project, upon which ANDE issue a Terms of Reference (ToR) for ESIA. On the basis of the ToR developed at the scoping stage and finally approved by ANDE, the actual ESIA work has commenced in January 2015, including the soil and land use investigation.

The Environmental Code requires that an ESIA process be undertaken by an environmental consultant who is approved by the Environmental Authority (ANDE) responsible for the administrative approval process. For this purpose Amec Foster Wheeler work in association with 2D Consulting, a local environmental consultancy officially accredited in Côte d'Ivoire.

Purpose of the Study

This report details the findings of the baseline soil, land use and land capability investigations for the proposed mining and beneficiation of the gold resource associated with the Yaoure Gold Mining Project, a development owned and managed by Amara Mining PLC (AMARA).

The specialist studies form part of the larger ESIA, with input to the baseline, impact assessment and management planning.

The purpose of the study is to:

- Verify and update the soil and land capability study carried out in 2007 as part of an earlier ESIA process;
- Characterize and classify the soil forms that occur in the exploration license area;
- Delineate sensitive soils, including wet based soils;
- Determine the capability of the various soil forms;
- Obtain land use information that will contribute to improving knowledge about the occupation and land use within the licence area;
- Assess potential impacts on soil, land use and land capability that may be caused by the mining operations; and
- Prepare a soil utilisation and management plan to ensure that potential impacts are mitigated and managed.

Methodology

The specialist soils and land capability information is considered as part of the larger ESIA and uses the IFC Performance Standards (2012) as guidance for the principles for best practice.

This soil and land capability specialist study was designed as the basis for the characterisation and classification of the different soil forms in the area, some of which may potentially be affected by the proposed activities. The norms utilised for the classification of the soils are based on a specific set of scientifically derived principles as set down in the "Taxonomic Soil Classification System, which is internationally recognised and consistent with the World Bank Standards.

The procedures followed consider both the physical and chemical characteristics of the in-situ materials, information which in turn is used with the overall geomorphology of the site in understanding the site sensitivities. This information is then combined into dominant soils "groups".

These groups have similar characteristics for which a similar set of impacts are common, and for which the same mitigation and management measures apply for any given activity. These can be used by the developer, and any interested or affected parties (Public and Authorities) to make informed and scientifically based decisions on the relative sustainability of the project on the soils and land capability.

In better understanding and informing these studies on how sensitive or vulnerable a soil or land capability is, it was essential that the system being used is able to establish and measure in a repeatable manner, the aspects and determinants that contribute to a material being robust or sensitive.

The classification and rating systems supply the scientific basis and knowledge needed to assess and measure the relative sensitivity or vulnerability of the materials to the different actions that are being proposed.

The area was initially divided on a three hundred meter grid base and the original soil study assessed at a desktop level. Extrapolation of information based on the 2007 soil information in combination with the geological mapping, terrain model and the infrared satellite imagery (all made available to the study by the client) was assimilated and used as the basemap for the 2015 studies (soil and land capability). The field study confirmed the 2007 study information and collected additional soil and geomorphological data from observations taken across the site at points accessible to the pedologist.

In addition, a set of composite samples (a set of samples taken from the soil auger points, with like soil forms being combined into one composite sample that is representative of a particular soil type/form) were taken of the different soil forms and submitted for analysis to determine the baseline chemistry across the study area. This sampling strategy is considered representative of an area with similar field characteristics.

The land capability is a function of the overall geomorphology of the area and considers the soil information as well as the climate, terrain (slope and aspect), the ground roughness, soil wetness factors and the national average for crop yield.

The land use was assessed by 2D Consulting Afrique using the infrared satellite imagery (GeoEyes) and site observation to verify an initial desktop delineation. The study was undertaken during January 2015, and concentrated on the land use and habitat types within the study area.

The soils' physical and chemical properties and the way in which these react to the elements (wind, water erosion, heat, chemical reaction etc.), the sensitivity to having the vegetative cover removed, or their vulnerability to having the topsoil disturbed, and the reaction of the materials to chemical inputs (ease of being taken into solution), are all aspects that were assessed in measuring sensitivity and ultimately vulnerability to development.

These measures will be important when the impact assessment is carried out, and will dictate the mitigation and management measures (degree of input etc.) that will be required.

It is essential to obtain sufficient site specific information that will ensure that the soils are adequately described and characterised to allow for an accurate assessment of the impacts of the actions that are being proposed by the developer and for the development of a conceptual soil utilisation guide and plan that is sustainable and practical.

At the outset, the baseline studies are needed as a record of the pre-development environment. These findings are useful for alternatives and the feasibility assessment, but must not be used for detailed engineering design.

The level of study and intensity (spatial variance) of the observations made was guided by a number of practical variables. These included the geomorphology of the site, a knowledge of the proposed development (mine plan) and the actions/activities that are planned.

Summary of Findings

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

The soils encountered on site can be broadly categorised into four major groupings (refer to Map Explanation – Figure 3.3 – Dominant Soils Map), with a number of dominant and sub dominant forms that characterise the area of concern.

The major soil forms are closely associated with the lithologies from which the soils are derived (in-situ formation) as well as the topography and general geomorphology of the site, with the effects of climate, topographic slope and attitude of the land forms affecting the pedogenisis/soil forming processes and ultimately the soil forms mapped.

In simplifying the trends the following major soil groupings pertain:

1. The deeper and more sandy loam soils are considered *High Potential* materials and are distinguished by the better than average depth (100cm to >150cm) of relatively much better drainage and moderate to good water holding capabilities within the soil rooting profile (80mm/m to 180mm/m).

   This group is recognisable by the complete lack of, or very subtle mottling (water within the profile for less than 30% of the season (designated the prefix - W1) at greater depths (>750mm on average), with a fine to medium grained texture, apedel to weak crumby structure and clays that range from as low as 12% to 18% in the top soil, and between 20% and 28% in the subsoil. These soils are generally founded on a ferricrete gravel or thick saprolitic layer, located mainly in the south central and south western sectors of the study area (Refer to Figure 3.3 – Dominant Soils Map).

   The land capability is rated as moderate intensity grazing land and/or moderate arable land capability depending on the nutrient and organic carbon stores and related production potential.

   These soils are generally slightly lower in clay than the associated wet based soils and more structured colluvial derived materials. The more sandy texture of this soil group renders them more easily worked and of a lower relative sensitivity (depth >750mm).

2. In contrast, the *shallower* and often slightly more *structured* materials are considered to be more *sensitive* and will require greater management if disturbed.

This group (<500mm) is associated almost exclusively with the sub outcropping of the parent materials or shallow lithocutanic/saprolitic horizons and are considered sensitive to moderately sensitive in terms of erosion, compaction and their workability. These sites have a relatively large and important function in the sustainability of the overall biodiversity of the area and will require management input if disturbed. The distribution of these materials appears to be lithologically controlled with a predominance in the southern and south eastern sectors of the study area (Refer to Figure 3.3 – Dominant Soils Map).

These soils comprise fine to medium grained sandy clay loams for the most part, returned structure that is apedel to moderate blocky at the extreme, with clay contents that range from 18% in the upper horizons to as high as 35% where the soils are associated with a more basic geology (dolerite).

3. The third group of soils comprises those that are associated with the hard pan ferricrete layer and perched/confined soil water. This group of soils has a set of distinctive characteristics and nature that are separated out from the other soil groupings due to their inherently much more difficult management characteristics.

   These soils are characterised by higher than average clay contents (18% to 25%) in the topsoil, and as high as 60% in the subsoil – are sometimes of a swelling nature (smectites), poor water intake rates, inhibited and poor drainage and returned at best moderately good water holding capabilities for the rooting profile (60mm/m to 100mm/m). This is particularly true in the case of the more platy and swelling clays which bind the soil water.

   The more structured nature of these soils and the inherent wetness are restrictive on rooting depths, while the hard pan nature of the ferricrete is also an inhibiting factor and a barrier within the top 500mm to 750mm of the soil profile. These soils are generally associated with a *wet or saturated basal horizon,* and are considered to be sensitive to highly sensitive in nature, albeit that they are generally considered to be of a "*relic"* land form.

   Large and significant areas of well-developed ferricrete outcrop/sheet outcrop were mapped within the study area and laterite is common within the vadose zone. The development of wet based soils and moist grassland environments were mapped in association with these soil forms.

   These soils will be more difficult to work in the wet state and more difficult to store and re-instate at closure.

   Again, it is noted as important to the baseline study that these soil groupings are moderately extensive in spatial area, and cover a significantly large proportion of the proposed development being planned (both mining and its infrastructure encroach).

   Additional management inputs and mitigation will be recommended for areas that rate as highly sensitive or valuable in terms of the soil and land capability.

4. In addition, and separated from the wet based structured soils are the group of soils that reflect *wetness* within the top 500mm. These soils are easily recognised by the mottled red and yellow colours on low chroma background to the soil. These soils are regarded as *highly sensitive* zones that will require management inputs if disturbed.

   The concentrations of natural salts and stores of nutrients within these soils are again a sensitive balance due to the extremes of rainfall (excessive leaching) and temperature, with leaching evident in the low chroma colours.

   The ability of a soil to retain moisture and nutrients, and in turn influence the sustainability of vegetative growth and dependence of animal life is determined by the consistency and degree of soil moisture retention within the profile but out of the influence of evaporation.

   The local conditions and associated site sensitivities are noted as aspects that effect the overall biodiversity balance, and it is important to understand that any development will inevitably affect and change the site conditions and impact on the environmental sustainability. These aspects will need to be managed and engineered to an acceptable level of sustainability (IFC PS 2012).

The wet based and very shallow soils are considered of high sensitivity and are vulnerable to being disturbed or worked on.

These soils will require added input and management if they are to be considered for development. The previous study undertaken in 2007 indicated a similar trend albeit that the study was more orientated towards better understanding the land capability potential and land use in the area of concern.

Soil wetness and the presence of hydromorphic conditions (wetlands) are considered important characteristics and these environments are rated as sensitive to highly sensitive, and areas that need to be flagged as sites requiring special attention.

A number of the activities being planned will impact directly on sensitive and in places highly sensitive sites, or are associated with the zone of influence that could affect these sites (Transition Zone Soils).

The land use mapping was used to characterizes the natural plant communities, and better understand the extent and types of farming, and other impacts of human activities (mining, locations, infrastructure etc.) in the area of concern. A land use and habitat map of Yaoure Gold Project was developed at a scale of 1:25,000.

The outcomes from the mapping indicate that the study site is divided into three areas. There are grassland and shrub land savannahs to the North and Northeast of the area, and forested/wooded Savannahs, and degraded and secondary forests to the South and Southwest.

Riparian forests/galleries are also present along the Bandama River.

Human activities involve a variety of land-use. These include the Kossou dam, artisanal and small scale commercial mining, existing mining infrastructure, a network of roads and tracks, as well as organised agriculture which is dominated by cocoa.

With the opening up of the area, the commercial cropping of Cocoa is increasing, with a spread of impact from the north and northeast (zone north of Angovia and Allahou-Bazi) towards the south and southwest (around Patizia). The study area comprises approximately 53% Savannah, 30% degraded and secondary forests (islets, galleries or riparian cover) and 13% cultivation and artisanal activities.

Summary of Potential Impacts

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

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

The impacts of the proposed development are associated with:

- The loss of the soil resource due the change in land use and the removal of the resource from the existing system (sterilisation);
- These effects are generally associated with the construction of the infrastructure and support facilities and the use of the footprint area for open cast mining activities. These activities will result in the loss of the soil resource for the life of the project and possibly for some time after closure;
- The management of waste rock and tailings will sterilise the soils permanently if the soils are not stripped and stored, and if not well managed;
- The loss of the soil resource due to the erosion (wind and water) of unprotected materials (removal of vegetative cover and/or topsoil);
- The loss of the utilization potential of the soil and land capability due to compaction of the footprint areas and areas adjacent to the constructed facilities;
- Loss of the resource due to removal of materials for use in other activities;
- The contamination of the resource due to spillage of raw materials or final product and the possibility of spillage of reagents transported to the site and used in the process;
- The contamination of stored or in-situ materials due to impacts of dust or dirty water from the project area and haulage ways/transport routes; and
- The loss of the soil utilisation potential due to the disturbance of the soils and potential loss of nutrient stores through infiltration and de-nitrification of the materials while in storage or due to disturbance of the materials.

The impact significance rating ranges from medium to very high during the construction phase if no mitigation is considered, to medium and low where the impacts are well managed.

The operational phase is a period where management of stockpiles of soil and the impacts of contamination of the resource need to be considered and implemented as part of the daily housekeeping.

During decommissioning phase and where rehabilitation can feasibly be undertaken ahead of closure, and during the closure phase the impacts will vary from high on areas where large machinery is utilised to positive and medium on the areas where re-establishment of the surface landscape is possible. The use of mine water for road wetting, dust suppression and irrigation will need to be considered carefully if the impacts of contamination of the stored soils and surrounding (in-situ) materials are to be managed.

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GLOSSARY

Alluvium: Refers to detrital deposits resulting from the operation of modern streams and rivers.

Base status: A qualitative expression of base saturation.

Buffer capacity: The ability of soil to resist an induced change in pH.

Calcareous: Containing calcium carbonate (calcrete).

Catena: A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage.

Clast: An individual constituent, grain or fragment of a sediment or sedimentary rock produced by the physical disintegration of a larger rock mass.

Cohesion: The molecular force of attraction between similar substances. The capacity of sticking together. The cohesion of soil is that part of its shear strength which does not depend upon inter-particle friction. Attraction within a soil structural unit or through the whole soil in apedel soils.

Concretion: A nodule made up of concentric accretions.

Crumb: A soft, porous more or less rounded ped from one to five millimetres in diameter. See structure, soil.

Cutan: Cutans occur on the surfaces of peds or individual particles (sand grains, stones). They consist of material which is usually finer than, and that has an organisation different to the material that makes up the surface on which they occur. They originate through deposition, diffusion or stress. Synonymous with clayskin, clay film, argillan.

Denitrification: The biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen.

Erosion: The group of processes whereby soil or rock material is loosened or dissolved and removed from any part of the earth's surface.

Fertilizer: An organic or inorganic material, natural or synthetic, which can supply one or more of the nutrient elements essential for the growth and reproduction of plants.

Fine sand: (1) A soil separate consisting of particles 0.25-0.1mm in diameter. (2) A soil texture class (see texture) with fine sand plus very fine sand (i.e. 0.25-0.05mm in diameter) more than 60% of the sand fraction.

Fine textured soils: Soils with a texture of sandy clay, silty clay or clay.

Hardpan: A massive material enriched with and strongly cemented by sesquioxides, chiefly iron oxides (known as ferricrete, diagnostic hard plinthite, ironpan, ngubane, ouklip, laterite hardpan), silica (silcrete, dorbank) or lime (diagnostic hardpan carbonate-horizon, calcrete). Ortstein hardpans are cemented by iron oxides and organic matter.

Land capability: The ability of land to meet the needs of one or more uses under defined conditions of management.

Land type: (1) A class of land with specified characteristics. (2) In South Africa it has been used as a map unit denoting land, mapable at 1:250,000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

Land use: The use to which land is put.

Mottling: A mottled or variegated pattern of colours is common in many soil horizons. It may be the result of various processes *inter alia* hydromorphy, illuviation, biological activity, and rock weathering in freely drained conditions (i.e. saprolite). It is described by noting (i) the colour of the matrix and colour or colours of the principal mottles, and (ii) the pattern of the mottling. The latter is given in terms of abundance (few, common 2 to 20% of the exposed surface, or many), size (fine, medium 5 to 15mm in diameter along the greatest dimension, or coarse), contrast (faint, distinct or prominent), form (circular, elongated-vesicular, or streaky) and the nature of the boundaries of the mottles (sharp, clear or diffuse); of these, abundance, size and contrast are the most important.

Nodule: Bodies of various shapes, sizes and colour that have been hardened to a greater or lesser extent by chemical compounds such as lime, sesquioxides, animal excreta and silica. These may be described in terms of kind (durinodes, gypsum, insect casts, ortstein, iron, manganese, lime, lime-silica, plinthite, salts), abundance (few, less than 20% by volume percentage; common, 20 – 50%; many, more than 50%), hardness (soft, hard meaning barely crushable between thumb and forefinger, indurated) and size (threadlike, fine, medium 2 – 5mm in diameter, coarse).

Overburden: A material which overlies another material difference in a specified respect, but mainly referred to in this document as materials overlying weathered rock.

Ped: Individual natural soil aggregate (e.g. block, prism) as contrasted with a clod produced by artificial disturbance.

Pedocutanic, diagnostic B-horizon: The concept embraces B-horizons that have become enriched in clay, presumably by illuviation (an important pedogenic process which involves downward movement of fine materials by, and deposition from, water to give rise to cutanic character) and that have developed moderate or strong blocky structure. In the case of a red pedocutanic B-horizon, the transition to the overlying A-horizon is clear or abrupt.

Pedology: The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.

Slickensides: In soils, these are polished or grooved surfaces within the soil resulting from part of the soil mass sliding against adjacent material along a plane which defines the extent of the slickensides. They occur in clayey materials with a high smectite content.

Sodic soil: Soil with a low soluble salt content and a high exchangeable sodium percentage (usually EST > 15).

Swelling clay: Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as heaving soils.

Texture, soil: The relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page). The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided (see diagram) according to the relative percentages of the coarse, medium and fine sand subseparates.

Vertic, diagnostic A-horizon: A-horizons that have both, a high clay content and a predominance of smectitic clay minerals possess the capacity to shrink and swell markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet.

1.0 INTRODUCTION

Amara Mining PLC (Amara) is a public limited company trading on the London Stock Exchange (AIM market), with its head offices in London, UK. Amara is seeking to develop its 100 percent owned Yaoure Project in the Department of Bouafle in the Ivory Coast, or Côte d'Ivoire. The Yaoure Project is presently in the prefeasibility stage of development.

As part of its prefeasibility work, Amara is carrying out an Environmental and Social Impact Assessment (ESIA) process, in compliance with the Ivorian Mining Code, Environment Management and Protection Code and Application Decree, as well as the IFC Performance Standards on Environmental and Social Sustainability. Amara intends to complete the ESIA during the prefeasibility stage.

In December 2014, Amara retained Amec Foster Wheeler Earth & Environment (UK) Ltd. as lead consultants of the ESIA. The ESIA is based on the Scoping Report that was prepared by AMEC Earth & Environmental UK Ltd. (now Amec Foster Wheeler) and submitted to the environmental regulatory authority (ANDE) in November 2014.

The ESIA process in Côte d'Ivoire is guided by Code No 96-766 of 3 October 1996 and Decree No. 96-894 of November 1996. In terms of the Code the first step in the ESIA process is to submit a Technical Report to ANDE which contains a description of the project, upon which ANDE issue a ToR for ESIA. On the basis of the ToR developed at the scoping stage and finally approved by ANDE, the actual ESIA work has commenced in January 2015. Earth Science Solutions (Pty) Ltd were retained as part of the specialist team commissioned to assess and investigate the impact that mining might have on the soils, d land capability and land use in the study are, with emphasis on the more sensitive wetlands.

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

The ESIA process serves two functions:

1. To provide the basis for decision-making, by the authorities and Project stakeholders on the environmental acceptability of the project; and

2. To provide input to the project design as it evolves, on an iterative basis, to minimise negative impacts and maximise the benefits of the Project.

In keeping with these basic requirements, the objectives of the soils and land capability specialist studies include:

- The documentation of the soil and land capability baseline conditions (pre-project conditions) of the study area and the socio-economic conditions of the affected communities in terms of the pre development land use;
- Inform, obtain and address contributions from stakeholders including relevant authorities and the public that pertain to the soils, land capability and land use aspects;
- Assess, the earth science and social impact that would result from the project, and compare the impacts with national and/or international environmental and social standards;
- Provide a permanent record of the present soil resources in the area that are potentially going to be affected by the proposed development (Pre mining and beneficiation environment);
- Assess the nature of the site in relation to the overall environment and its present utilisation/land capability potential;
- Provide a base plan from which long-term ecological and environmental decisions can be made, impacts of mining can be determined, and mitigation and rehabilitation management plans can be formulated;
- Assess the impacts of mining and its associated activities on the different phases of the project from construction to operation through to closure;
- Identify mitigation measures that would reduce the significance of predicted negative impacts or enhanced predicted benefits of the proposed mining projects, through a suite of Environmental/Social Management Plans (ESMP); and
- Develop appropriate soil monitoring plans for project.

The Taxonomic Soil Classification System and Canadian Land Inventory System in combination with the British Land Capability Rating Systems were used as the basis for the soils and land capability investigations respectively. These systems are recognised internationally.

This baseline assessment has been addressed in line with the in national legislation and international guidelines for best practice as detailed in the IFC PS (2012) and forms part of the overall impact assessment, both as a standalone document and as supporting information to the overall ESIA for the proposed development.

The specialist Pedological and Land Capability studies where managed and signed off by Ian Jones (Pr. Sci. Nat 400040/08), an Earth Scientist with 36 years of experience in this field of expertise.

Ian Jones, and Earth Science Solutions (Pty) Ltd, are totally independent in this process, and have no vested interest in the Project.

1.1 Study Area

The Yaoure Gold Project (YGP) being investigated by AMARA is considered a brownfields project, with a significant amount of exploration having been completed with their resultant associated impacts, while the effect of artisanal mining, slash-and burn, commercial agriculture and some subsistence farming activities have had a significant impact on the natural environment over the last 60 to 80 years.

These activities had an effect on the ecosystem services and land capability of the area, while the change in land use has contributed to the socio-economics and welfare of the people.

In addition, some on-going and historical mining (commercial and artisanal) and its associated activities are evident within the study area. These activities e had a significant negative impact on the soil resources, land capability and the streams and river health, with the effects of these developments and activities noted during the field studies.

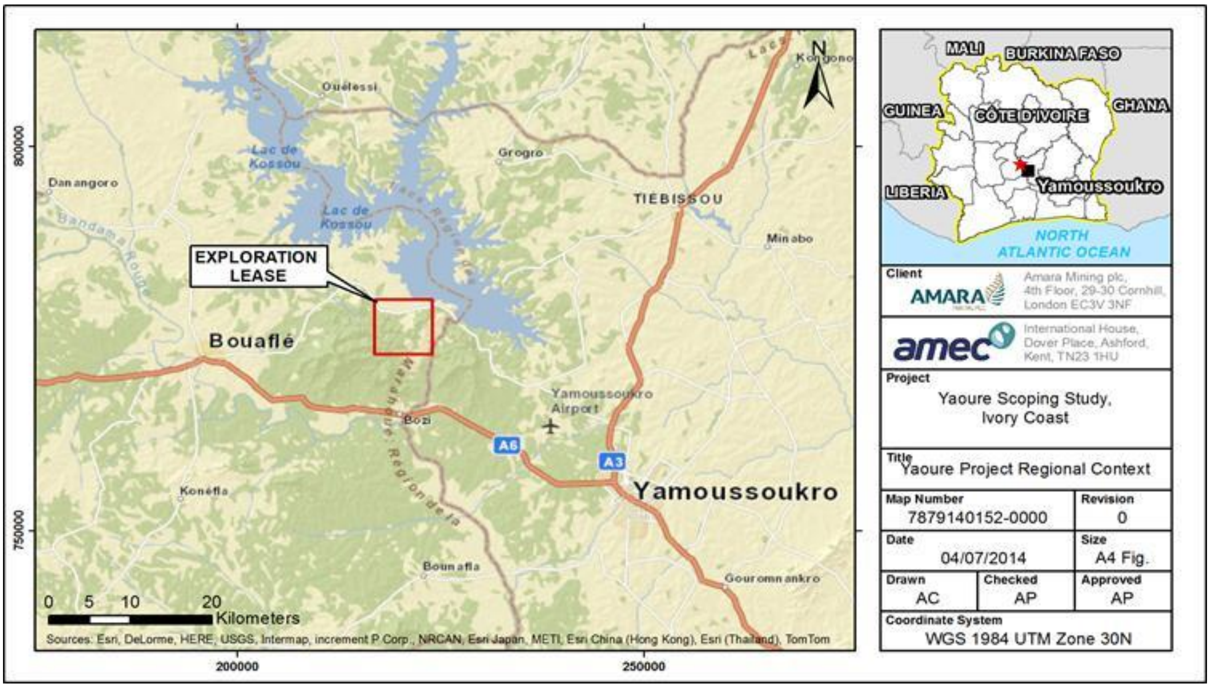
Both erosion and compaction are having impacts on the soil resource and the capability of the land, as well as affecting the streams and rivers with a significant sedimentary load. The area affected by these activities is relatively large and is considered to be significant in terms of the ecology and biodiversity of the area.

The area in question (Yaoure Project) is located in the south central portion of Côte d'Ivoire some 250 km northwest of Abidjan, and comprises large areas of artisanal mining an open pit and historical beneficiation plant and associated infrastructure (Refer to Figure 1.2).

It should be noted that this baseline study considered aspects of the Inner Exploration License and related alternative footprint areas for the TMF just outside the licence area, while also assessing and considering the potential for offsite influences that might be felt down gradient and downwind of the area if the erosion and soil cover are not well managed.

The influence of wind and water erosion could affect the streams and terrain downwind/downslope if soil is lost from the system. (Green line – Figure 1.2).

Figure 1.1: Locality Plan (Project Description – ESIA)



1.2 Project Description

Amara is in the process of applying for a mining license for the Project. The process proposed involves the mining of gold by open cast bench mining using the truck and shovel system of extraction. The beneficiation of the gold will be undertaken on site, with a significant waste stream of both waste rock and tailing, being produced as a by-product of the process.

In addition to the extension to the existing open pit structure that is planned to the west of the existing open pit, a number of additions to the support infrastructure will be needed to cater for the additional volumes of ore that will need to be processed as well as to cater for the additional waste streams (waste rock, tailings and dirty water).

The mining will require a system of haulage ways and access routes to link the pit to the beneficiation works, and support infrastructure that will see the tailings piped to the TMF, while the excess water will be returned to the processing facility/ plant, with the waste rock being trucked to WRD1 and WRD2.

In addition, there will be a need for a contractors camp, staff quarters within a structured village, administration buildings, offices, workshops, and a number of stockpiles to cater for the for the Run-of-Mine (RoM) materials as well as stores of soil and soft overburden materials that will need to be located close to the position of re-use for closure and rehabilitation (Figure 1.3 – Mine Plan).

Figure 1.2: Licence Areas (Terms of Reference)

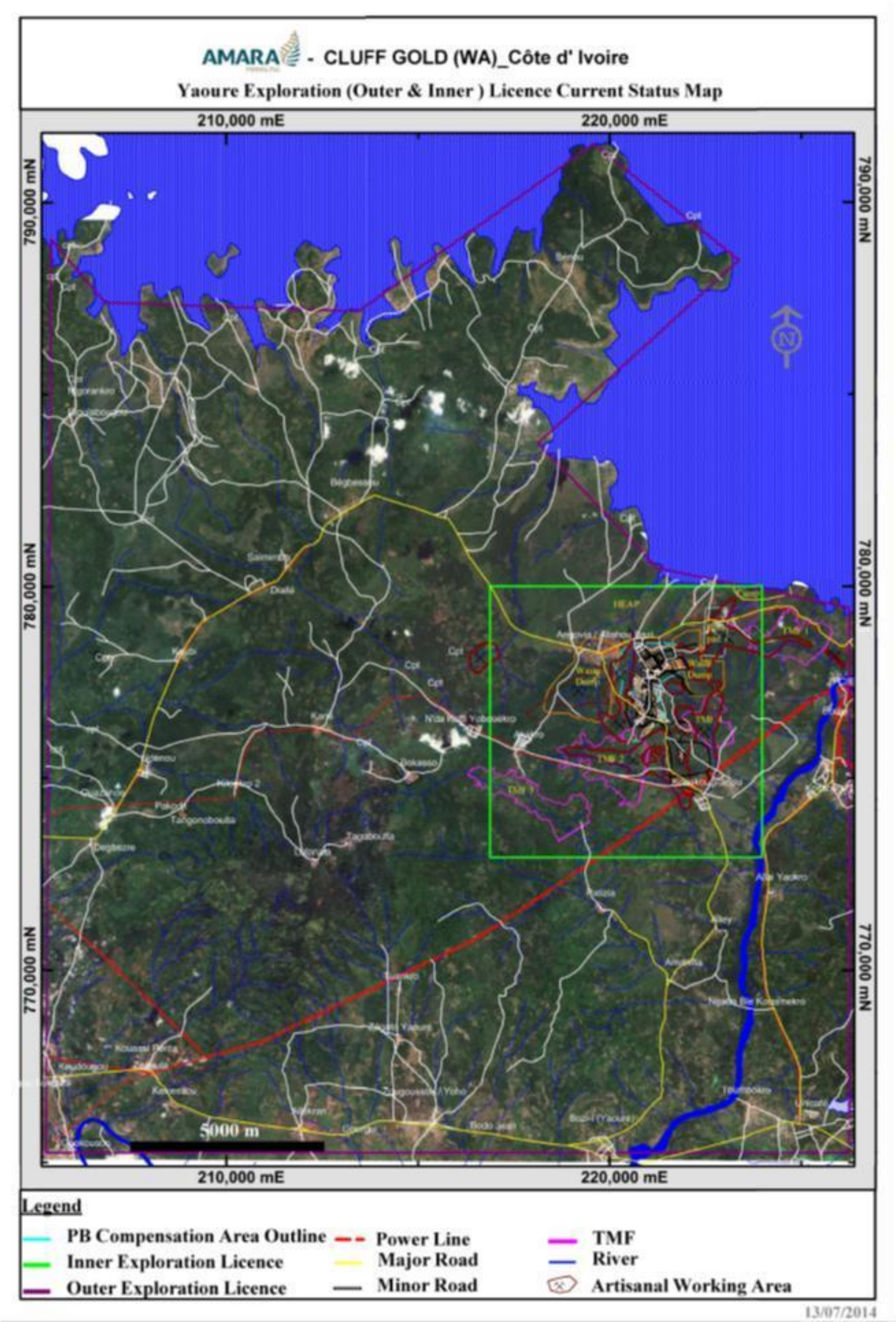
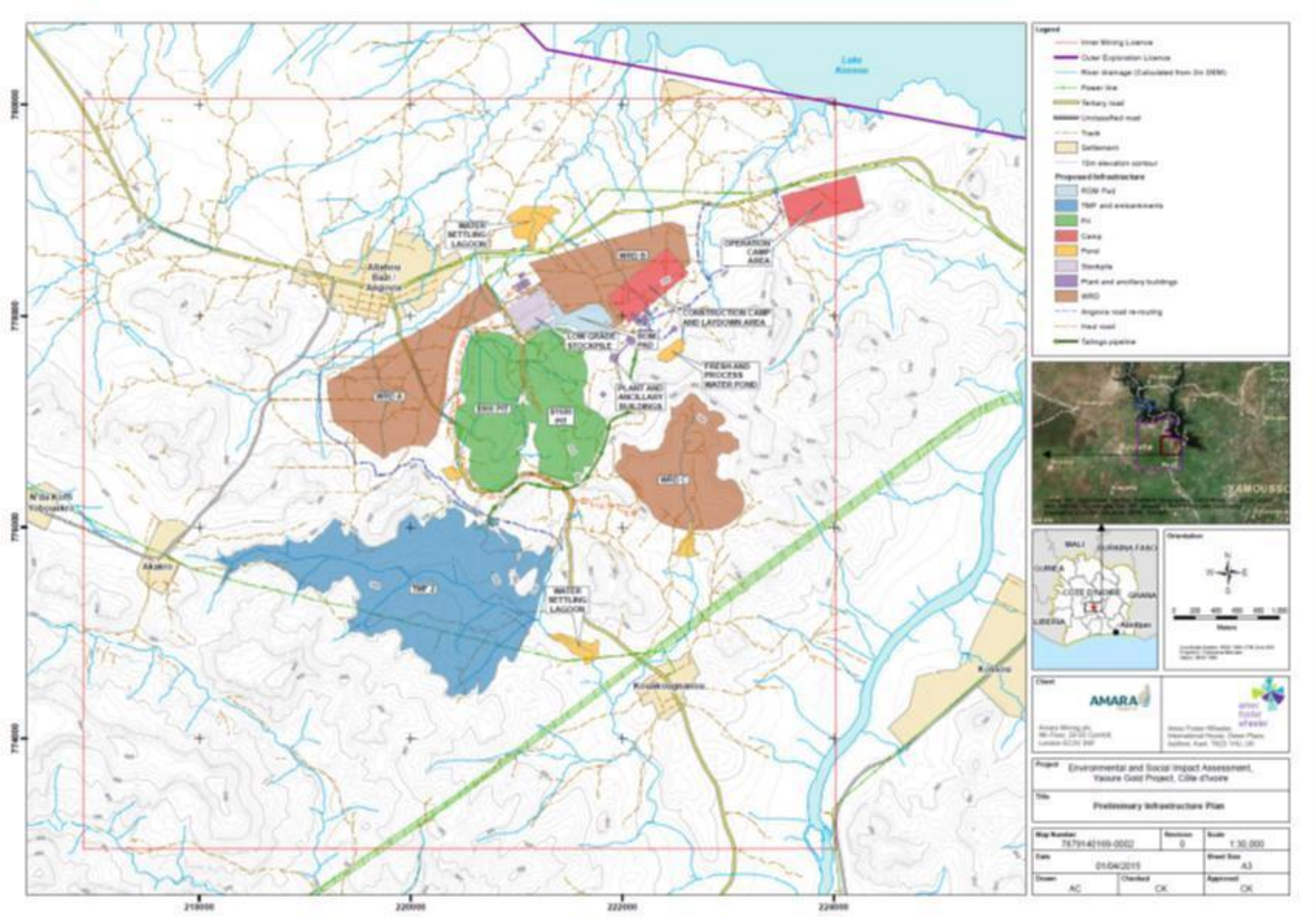


Figure 1.3: Preliminary Infrastructure Plan (April 2015 - ESIA)



The open cast mining will result in the stockpiling of soils and significant amounts/quantities of soft overburden if these materials are going to be used to their optimum potential.

The proposed mining and its associated activities will result in a number of changes and potential negative impacts to the overall environment due to the disturbance of the surface features. These impacts must be managed and minimised as far as possible. These include the soils, which in turn will have an effect on the capability of the land and its functionality.

1.3 Soil and Land Use Study

In an attempt to quantify the potential impacts that might result, and in order to meaningfully develop a management plan that can mitigate the effects of the planned activities it was imperative that the pre-development aspects and baseline conditions are understood and documented.

The relative coverage proposed for the soils, land capability and land use baseline studies were tailored to obtain sufficient scientifically derived information that a statistically reliable information set was available, and that the information could be used for the assessment of impacts and the design of a meaningful management plan for mitigation and minimisation.

These studies are **not** intended, and must not be used for engineering designs other than the soil stripping and rehabilitation planning, the considerations or relocation of people and their activities, and the assessment of the site for relocation. Additional detailed geotechnical evaluations for materials sourcing and use are essential for any engineering purposes, while detailed agronomic input will be needed for crop choice and land utilisation.

One of the more important outcomes of the soil characterisation and classification exercise was the delineation and characterisation of dominant soils and the rating of the soil sensitivity in terms of the activities being proposed. The grouping of soils with similar physical and chemical properties is considered important when large areas/footprints of land need to be managed as part of a development.

Small quantities/pockets of material cannot be managed separately when using large earth moving equipment, and it is therefore important that the soils are grouped into dominant groupings that can be managed in a similar manner.

These aspects are considered meaningful tools and systems that can be used to identify areas that will require added inputs and or consideration in terms of legal requirements and or licensing.

The effects of a mining project on the water bodies and agricultural developments require that soil wetness and the agricultural potential of the soils are assessed, with the IFC PS, 2012 making specific reference to the need for management of erosion and sedimentary load.

In addition to the grouping of like soils, the information obtained from the baseline studies is used to determine and catalogue the degree of “sensitivity” of the materials that are planned to be disturbed. These results have been used in measuring the relative impact significance.

This report has been compiled in line with the Guideline Document for Impact Assessment philosophy and Significance Rating System (Hacking et al., 2008), and the IFC PS, 2012 as the basis for best practice.

1.4 Purpose of the Study

This report details the findings of the baseline soil, land use and land capability investigations for the proposed mining and beneficiation of the gold resource associated with the Project, a development owned and managed by Amara Mining PLC (AMARA).

Any mining and beneficiation of the gold will result in by-products and waste products (tailings, waste rock, dirty water, dust etc.). This will need to be managed as part of the impact and management planning.

This specialist study forms part of the larger ESIA, with input to the baseline, impact assessment and management planning and monitoring requirements, and is aimed at more meaningfully obtaining a sustainable working plan for the project.

Open pit mining and subsequent processing of the ore, including waste management facilities (waste rock dumps, tailings facilities), roads and infrastructure will occur on the surface, and will therefore impact on the surface features (soils, water etc.), which in turn will impact the ecosystem services, the capability of the land and the land use.

The sustainability of any project requires that not only a profit is made in terms of the resource mined, but that there is sufficient return of the money made that the rehabilitation of the environment is possible at closure. The soil utilisation plan has been tailored to achieve this in terms of the soils, land use and land capability aspects of this project.

Apart from the environmental legal issues that are to be addressed, it is important that the potential loss of an important resource (soil and land use) is understood in terms of the sustainability equation, eco system services and the concept of “No Net Loss”.

The baseline mapping and characterisation of the soils has formed the basis from which the impact and effects on the land capability and land use have been measured.

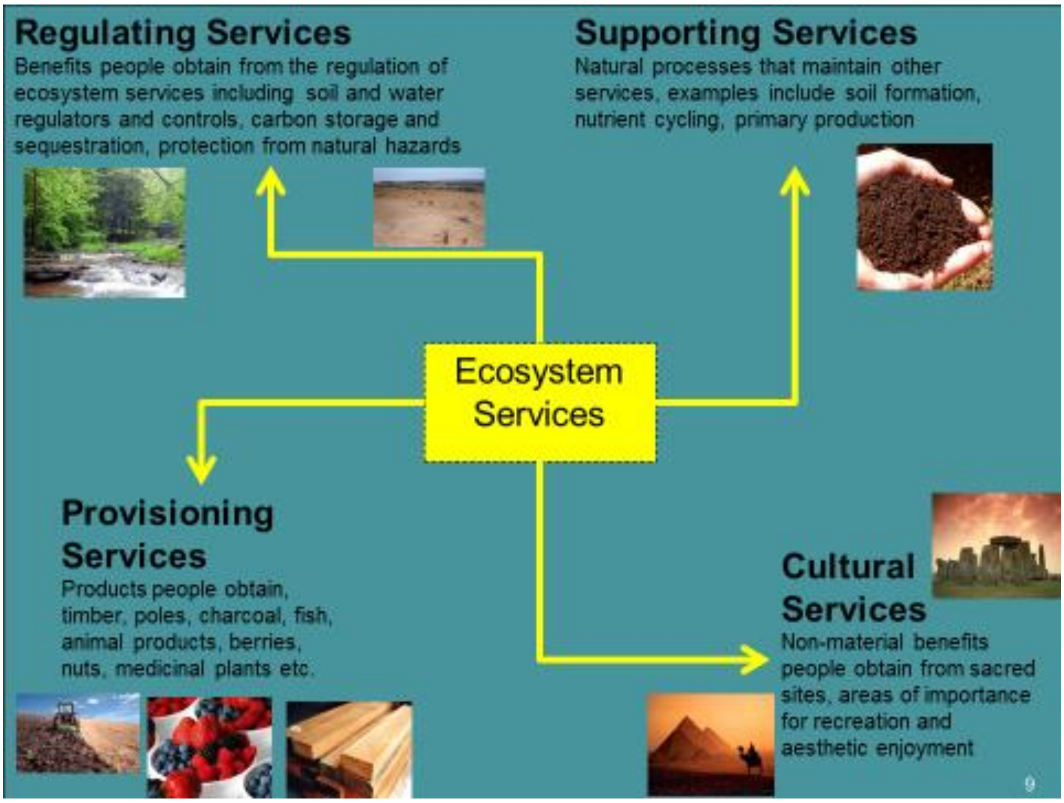
Based on the outcomes of the impact assessment, the site specific management planning and mitigation measures for the soils have been defined and detailed.

This included the defining of mitigating measures required to reduce the intensity and probability of the impact occurring. It is necessary to ensure that the prescriptive mitigation proposed is clear, site specific and practical.

In addition, and as part of the practical management plan, a comprehensive monitoring system has been proposed and tabled.

The soils and land capability are two of the specialist disciplines that have been considered important aspects of the physical environment, the ecosystem services (ES), all of which will be affected by the activities being proposed. It is incumbent on all developers (IFC Performance Std 6 of 2012) to assess the services that the natural environment (eco system) provides to the people and the planet.

Such services are called **'Ecosystem Services'** and are divided into four Services (Complements of IES Guidelines UK).



The study also makes provision for the assessment of the Project on land use. A separate land use survey was undertaken by a local specialist under supervision of Amec Foster Wheeler and ESS of which the findings, impact assessment and management requirements are incorporated in this report. These findings are considered together with the soils, a "supporting service" in the assessment of how the mining activities will impact on the people and the planet. Ecosystems (ES) that rate as "high" and of Critical Value will need to be managed and mitigation measures put in place as a matter of environmental sustainability. The rating of the ES Value is a function of the Socio Economic Studies. Soil and land capability are however considered as being of a High Critical value in the value chain and thus require an utilisation and management plan as part of the ESIA.

In the planning of any new development it is important that the impacts are understood prior to the initiation of the design and/or implementation of the project. The environmental aspects are part of the information that is needed in decision making, with an understanding of how the soils, land capability and land use will be affected being just part of the overall sustainability equation that needs to be balanced.

Figure 1.1 (Regional Locality Plan) shows the general location and extent of the proposed development that is planned and the extent of the mining right area, while Figure 1.2 (Mine License Areas) and Figure 1.3 (Mine Plan and Project Layout) show the mining license area and proposed mine layout/plan respectively.

The results of the soils and land capability have been discussed in terms of the "site sensitivity", with the soils mapping having been simplified based on the dominant soil forms and their associated land capability.

In this way, the sustainability of the project can be measured in terms of the impacts and related mitigation, with sensitive areas being managed ahead of any developmental impacts.

Based on the information available (mine plan) the reconnaissance baseline specialist studies for the soils and land capability have been completed for the proposed development. While the results of the land use survey have been provided by 2D Consulting Afrique and the potential impacts of the Project on land use assessed and included in this report.

The baseline findings have been used to assess and rank the impacts that can be expected, and the management plan for mitigation is based on the activities tabled as part of the development plan and the findings of the impact assessment.

A comprehensive soil utilisation plan is tabled as part of the Environmental Management Planning and describes how the soils should be managed if the impacts are to be minimised.

It is understood that the mining of gold and the related activities proposed for this project will definitely change the present land capability and land use with the strong possibility that there will be a loss of resource and ecosystem services from the overall system.

The activities will potentially have a medium to high negative impact on the natural resources for a significant period of time, and the present land uses (soils) and land capabilities will definitely be impacted and altered.

These activities will challenge the concept of "No Net Loss."

1.5 Desktop Findings

1.5.1 Previous Studies

A previous soil, land use and land capability study undertaken of the area in question in 2007 as part of a previous ESIA for Cluff Gold, was made available to the specialist team.

The specialist soils report was translated electronically using the "google" app with some success, while the terrain model geological mapping, general geomorphological information and initial land use map where all assimilated and used as part of the baseline.

The 2007 Soil Study covered a significant area within the mining license holding, with the village of Angovia forming the main town/village within the area of concern. Artisanal mining and the exploitation of gold has been on-going by both small scale commercial enterprises as well as a large number of artisanal miners for almost a century.

The study was conducted at a scale of 1:50 000 at the request of CECAF International and on behalf of SGS as part of the larger ESIA required for mineral exploitation.

The main findings from this study relate to the ability of the soils and land form to sustain agriculture, a measure of land capability, with the area of concern being broadly divided into groupings, a similar approach as was taken in the latest study.

The groupings take cognisance of the geomorphology in conjunction with the soils. The study concludes that:

- The weathered profiles are generally deep other than where with ferricrete forms a hard lateritic surface at or close to surface;
- The rooting zone is generally between 300mm and 1,200mm deep;
- The shallower soils associated with significant proportions of angular to sub angular inclusions ranging from coarse gravel to cobble sized material. These soils are classified as sandy clay loams for the most part, and are confined predominantly to the south and south eastern sectors;
- Deeper soils return good water holding capabilities, sandy to sandy clay texture and apedel to weak crumby structure, are moderately well drained and are considered moderate to good arable potential soils;
- Large areas of "Rafts/Platform" structures associated with hard pan ferricrete (iron rich lithologies) were mapped returning shallow to very shallow rooting depth and/or outcrop; and
- The type areas are considered and have been included in the 2015 survey.

The mapping has been included as a reference to the study, and the mapping used as the baseline to this recent study (Refer to Figure 3.2 – 2007 Soil Study Map).

The 2007 Soil Study information was used as the baseline to the current soil study. The 2007 study included a significant number of observations which have been made and described as part of the study. Pit profiles and soil descriptions for the entire area were plotted and used to great effect as the base plan to this study. With the geomorphology considered and the terrain model assimilated with the soils data, a good idea of the soil distribution across the study area was understood and the soil patterns could be interpolated.

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

The geology of the Yaoure deposit area is relatively simple. The majority of the Project area is underlain by mafic volcanics, which are predominantly massive and in the form of pillowed basalts.

The north part of the area is intruded by massive granodiorite that locally has a subtle porphyritic texture. Elsewhere, but mainly associated with the main Yaoure Zone, there are numerous porphyry sills. A volcanoclastic unit, mainly of epiclastic origin, is situated near the contact of the granodiorite to the north.

The granodiorite intrusive to the north is not mineralised while the one in the Yaoure pit contains quartz veins which are well mineralised.

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

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

All of the above rocks have been intruded by basic to ultra-basic plutonic rocks and acidic intermediate calc-alkaline volcano-plutonic rocks and the whole package is in turn overlain by the Benou polygenic conglomerate.

All of these have been deformed by a series of east west striking shear zones and intruded by associated greyish quartz veining.

Primary and secondary lateritic weathering profiles have also developed throughout the area above the conglomerate. The gold mineralisation itself appears to be primarily located in structurally controlled alteration zones in intermediate volcanic rocks.

The 2014 Preliminary Economic Assessment (PEA) Report indicates that there is a major NE-trending regional fault passing through the Yaoure Central pit. Movement along this fault line generated two additional NNE-SSW trending faults branching into the Yaoure gold deposits (Refer to Figure 1.4). Some additional geological structures have been identified by Steenkamp in 2012. Structures have the potential to act as pathways for groundwater and could either lead to seepage into the pit or transportation of potential contaminants into groundwater resources. It could also act as containment barriers. The potential linkage of structures to surface water resources will have to be further investigated as part of the Definitive Feasibility Study (DFS) and hydrogeological investigation.

Figure 1.4: Geology of the Yaoure Project (Source: Amara Mining)

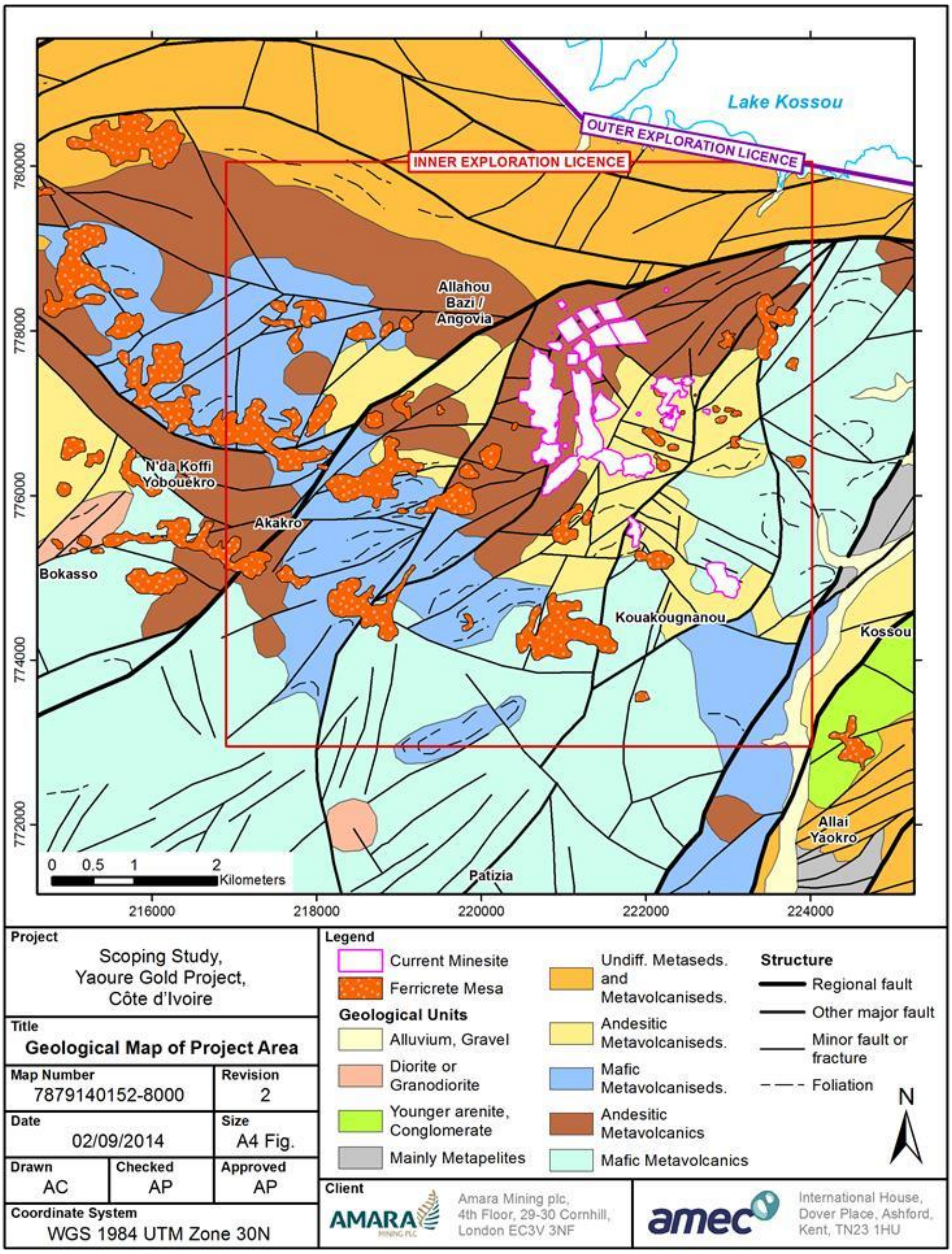
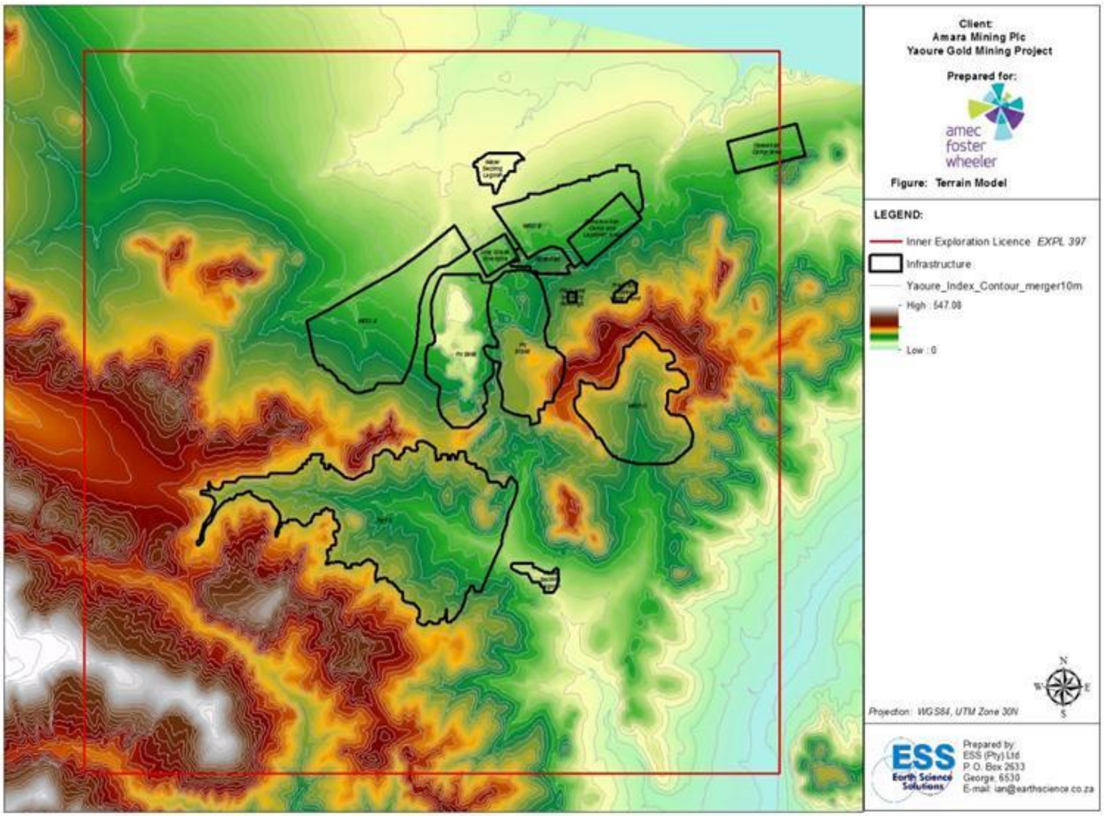


Figure 1.5: Terrain Model



1.6 Legal Requirements

Environmental Legal Requirements of Côte d'Ivoire.

The ESIA process in Côte d'Ivoire is guided by Code No 96-766 of 3 October 1996 and Decree No. 96-894 of November 1996. In terms of the Code the first step in the ESIA process is to submit a Technical Report to ANDE which contains a description of the project, upon which ANDE issue a ToR for ESIA. On the basis of the ToR developed at the scoping stage and finally approved by ANDE, the actual ESIA work has commenced in January 2015.

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

Of direct consideration the following articles are pertinent to the soils and eco system services associated with the resource. These include:

- Article 35.3 requires the preservation of biological diversity;

- Article 35.4 requires to prevent degradation of natural resources and to strive for sustainable development. Irreversible effects on land should be avoided as far as possible; and
- Article-35.5 introduces the "polluter pays" principle: any natural or legal person whose actions and/or activities are causing or are likely to cause damage to the environment is liable to financial compensation.

Further to these direct legal considerations, the laws of the land also make reference and protect the “Land Use” and exploitation and resettlement of land.

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

Expropriation for public purposes is governed in Côte d'Ivoire by Decree of 25 November 1930, which provides in article 1 "expropriation for public purposes takes place in French West Africa after decision by a judge."

The expropriation procedure stipulates the following:

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

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

- In-kind compensation;
- Land with and without equipment;
- Cash compensation; and
- A combination of in-kind and cash.

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

In addition, as part of best practise and the potential for international monetary assistance (loans), the proponent requires that the IFC Performance Standards, 2012 are considered.

The IFC has developed a series of Performance Standards to assist developers and potential clients in assessing the environmental and social risks associated with a project and assisting the client in identifying and defining roles and responsibilities regarding the management of risk.

1.6.1 International Requirements and Best Practice

Performance Standard 1 establishes the importance of:

- Integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects;
- Effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and
- The client's management of social and environmental performance throughout the life of the project.

Performance Standards 2 through 8 establish requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate.

While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the client is required to manage them through its Social and Environmental Management System consistent with Performance Standard 1.

Of importance to this report are:

- The requirements to collect adequate baseline data;
- The requirements of an impact/risk assessment;
- The requirements of a management program;
- The requirements of a monitoring program; and most importantly
- To apply relevant standards (either host country or other).

With regard to the application of relevant standards (either host country or other) there are no specific quantitative guidelines relating to soils and land use/capability, either locally or within the World Bank's or IFC's suite of Environmental Health and Safety Guidelines.

The plan should include measures appropriate to the situation to intercept, divert, or otherwise reduce the storm water runoff from exposed soil surfaces, tailings dams, and waste rock dumps.

Project sponsors are encouraged to integrate vegetative and non-vegetative soil stabilization measures in the erosion control plan.

Sediment control structures (e.g., detention/retention basins) should be installed to treat surface runoff prior to discharge to surface water bodies. All erosion control and sediment containment facilities must receive proper maintenance during their design life.

This will be included in the appropriate management plans when they are developed at a later stage in the project's life cycle.

1.7 Report Structure

This specialist report considers the soils, land capability and land uses for the site specific study area as delineated, and has investigated the pre development conditions for the brownfields study area as the basis for the impact assessment.

Using this baseline information and the previous soils study and the 2015 Land Use Report (Refer to Appendix 3) in conjunction with the terrain model, geological mapping, geomorphological and project description all of which was made available by the client, the impacts were rated in terms of their significance as a function of the proposed activities being planned.

Based on the outcomes of the ESIA a number of management measures have been tabled as part of the soil utilisation strategy to assist in minimising and where possible mitigating the impacts.

2.0 METHODOLOGY

2.1 Background Physiography

The soil and land capability studies are designed as the basis for the characterisation and classification of the different soil forms and the rating of the capability of the land, all of which will potentially be affected by the proposed activities. These norms are based on a specific set of principles as set down in the “Taxonomic Soil Classification (Mac Vicar et al 1991), and the Canadian Land Inventory System systems that are compatible with international standards, and consistent with the requirements of the IFC PS, 2012 and World Bank Standards. The land use study (2D Consulting Afrique) is based on the GeoEyes satellite imagery (04/01/2014) and the ENVI 4.8 and ArcGIS 10.1 software.

The resultant physical and chemical characteristics of the materials the climate, ground roughness, topographic slope and overall geomorphology of the site are used to characterise and highlight the site specific sensitivities which are then combined into dominant soil “groups” and land capability ratings.

The groupings comprise soils that have similar characteristics for which a set of impacts are common, and for which the similar management measures apply for any given activity. These can be used by the developer for decision making and management, while the stakeholders and/or interested and affected parties and land users (Public and Authorities) can make informed and scientifically based decisions on the relative sustainability of the project in terms of these specialist aspects (soils, land capability and land use).

In better understanding and informing these studies on how sensitive or vulnerable a soil or land capability is, it was essential that the system being used was able to establish and measure in a repeatable manner, the aspects and determinants that contribute to a material being robust or not.

The classification and rating systems supply the scientific basis and knowledge needed to assess and measure the relative sensitivity or vulnerability of the materials to the different actions that are being proposed.

The soils physical and chemical properties and the way in which these react to the elements (wind, water erosion, heat, chemical reaction etc.), the sensitivity to having the vegetative cover removed, or their vulnerability to having the topsoil disturbed, and the reaction of the materials to chemical inputs (ease of being taken into solution), are all aspects that have been assessed in measuring sensitivity and ultimately vulnerability to development.

2.2 Survey Period and Area Covered

At the outset, the baseline studies are needed as a record of the pre-development environment of the current brownfields site. These findings are useful for alternatives and the feasibility assessment, but must not be used for detailed engineering design. It is also important that the findings of this study are able to deal with, and wherever possible answer the questions relating to the issues and concerns regarding land use and land capability that have been or might be raised by the public (IAP's).

The study area (delineated by the client – January 2015) was investigated during February and March of 2015 (22 February 2015 to 01 March 2015) using the existing soils study (2007) and associated earth science information (geology and geomorphology – ESIA 2015) as the basis for the comprehensive baseline of information, and infilling using a reconnaissance scale study (2015) with special emphasis on the wetland issues and sensitive land forms within the area of concern.

The level of study and intensity (spatial variance) of the observations made was guided by a number of practical variables. These included the level of existing information (geology, geomorphology and terrain modelling), available for the site, the spatial distribution of the available information and a knowledge of the proposed development (mine plan) and the actions/activities that are planned. Added to these aspects are the relative sensitivity of the materials (wetness etc.) and their spatial distribution in relation to the proposed infrastructural development.

In addition to the additional observations made, a representative selection of the soil forms mapped were sampled and analysed to determine their chemistry and physical attributes.

The soil mapping was undertaken on a 1:20,000 scale (Refer to Figure 3.3 – Dominant Soils) orthophotographic base (LiDAR Imagery).

2.3 Sampling Methodology

Standard mapping procedures and field equipment were used throughout the survey, with the soil profiles being examined using a hand operated auger and any natural exposures (pits and road cuttings), and soil samples (0.2kg) being submitted for analysis. The system of profiling and sample compilation is described later in the section of survey methodology.

The fieldwork comprised five days on site during which profiles of the soil were examined and observations made of the differing soil extremes. Relevant information relating to the climate, geology, soil wetness and terrain morphology were also considered and used in conjunction with the classification of the soils, while the numerous exposures created by the artisanal mining and clearing for agricultural activities assisted in the soil mapping. Variation in the natural vegetation, although very dense and impenetrable for the most part was used to help in the more accurate placing of the changes in soil form.

The study area was initially assessed at a desktop level using the aerial imagery and a broad grid base to delineate and assimilate the baseline of information. This information was then used as the basis for the site evaluation. Roads and tracks were used to access the site, with observations made were obvious changes in the lithologies were noted and/or were soil colour changed. Extrapolation of information across areas that were not mapable on the ground was necessary in order for the compilation of data.

The pedological study was aimed at investigating/logging and classifying the soils within the alternative areas of potential disturbance, with specific emphasis having been made on the soil wetness index and the relative sensitivity of the wet based materials to disturbance.

Terrain information, topography and any other infield data of significance was also recorded, with the objective of identifying and classifying the area in terms of:

- The soil types to be disturbed/rehabilitated;
- The soil physical and chemical properties;
- The soil depth;
- The erodibility of the soils;
- Pre-construction soil utilisation potential; and
- The soil nutrient status.

The identification and classification of soil profiles were carried out using the *Taxonomic Soil Classification System (Mac Vicar et al, 2nd edition 1991*).

The Taxonomic Soil Classification is a very simple system that employs two main categories; an upper level or general level containing Soil Forms, and a lower, more specific level containing Soil Families.

Each of the soil forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons and materials.

All soil forms are subdivided into two or more families, which have in common the properties of the Form, but are differentiated within the Form on the basis of their defined properties.

In this way, standardised soil identification and communication is allowed by use of the names and numbers given to both Form and Family.

The procedure adopted in the field when classifying the soil profiles is as follows:

i. Demarcate master horizons;

ii. Identify applicable diagnostic horizons by visually noting the physical properties:

    - Depth (below surface);
    - Texture (Grain size, roundness etc.);
    - Structure (Controlling clay types);
    - Mottling (Alterations due to continued exposure to wetness);
    - Visible pores (Spacing and packing of peds);
    - Concretions (cohesion of minerals and/or peds);
    - Compaction (from surface);

iii. Determine from i) and ii) the appropriate Soil Form; and

iv. Establishing provisionally the most likely Soil Family.

Table 2.1: Arrangement of Master Horizons in Soil Profile (Soil Classification – Mac Vicar 1991)

<table>
<tr><td rowspan="11">SOLUM</td><td rowspan="11">(Zone in which the soil forming processes are maximally expressed)</td><td colspan="5">Arrangement of master horizons</td><td>Comments on Layers</td></tr>
<tr><td rowspan="10">O - Organic</td><td rowspan="5">C - Regic Sands (C), Stratified Alluvium (C), Man - Made Soil Deposits (C).</td><td rowspan="2">A</td><td rowspan="2">Humic,Vertic, Melanic, Orthic</td><td rowspan="10">G</td><td>Loose leaves and organic debris, largely undecomposed</td></tr>
<tr><td>Organic debris, partially decomposed or matted</td></tr>
<tr><td rowspan="3">B</td><td rowspan="3">Red Apedel, Yellow-brown Apedel, Soft Plinthic, Hard Plinthic, Prismacutanic, Pedocutanic, Lithocutanic, Neocutanic, Neocarbonate, Podzol, Podzol with placic pan</td><td>Dark coloured due to admixture of humified organic matter with the mineral fraction</td></tr>
<tr><td>Light coloured mineral horizon</td></tr>
<tr><td>Transitional to B but more like A than B</td></tr>
<tr><td rowspan="4">C</td><td colspan="2" rowspan="4">Dorbank, Soft Carbonate horizon, Hard Carbonate Horizon, Saprolite, Unconsolidated materials without signs of wetness, Unconsolidated materials with signs of wetness, Unspecified materials with signs of wetness</td><td>Transitional to A but more like B than A</td></tr>
<tr><td>Maximum expression of B-horizon character</td></tr>
<tr><td>Transitional to C</td></tr>
<tr><td>Unconsolidated material</td></tr>
<tr><td colspan="3">R - Hard Rock</td><td>Hard rock</td></tr>
</table>

2.4 Analyses

Sampling of representative soils was carried out and submitted for analysis to an accredited laboratory in South Africa (Agricultural Research Council – ARC). A total of ten (10) composite samples (samples comprising more than one sample point into a single sample of similar or like soil) were submitted for analysis.

Factors that were considered in the laboratory included:

- Determination of the pH;
- Exchangeable bases;
- C.E.C. (cation exchange capacity);
- Texture (% clay);
- Nutrient status; and
- Any potential pollutants.

The methods employed in the determination of the above variables are:

i) The Spectro Atomic Analyser for the determination of the basic elements;

ii) The titration method for the determination of Organic Carbon contents; and

iii) The use of a density meter for the determination of the clay contents.

Analytical results are given for the extractable quantities available from the soil (refer to Table 3.1).

3.0 RESULTS

3.1 Soil Characterisation

3.1.1 General

The soils encountered can be broadly categorised into four major groupings, with a number of dominant and sub dominant forms that have been grouped and that characterise the area of concern (Refer to Figure 3.3 – Dominant Soils Map).

The major soil forms are closely associated with the lithologies from which the soils are derived (in-situ formation) as well as the topography and general geomorphology of the site, the effects of topographic slope and attitude of the land forms affecting the pedogenetic processes of soil formation and ultimately the soil forms mapped. The resultant site map is a composite of the more detailed pedological information that is more easily utilised in the mining environment. The combination of soils and land capability are then considered in terms of the site sensitivity, a variable considered useful and important when assessing the impacts that any development might have on the natural environment. (Refer to Figure 3.4 – Site Sensitivity Map).

The generally undulating to moderately steep topography coupled with the high rainfall and storm intensities has resulted in the deep weathering and transportation of soils downslope on areas that have been exposed (vegetation removed and/or topsoil's disturbed). The resultant development of colluvial accumulations and alluvial flood plain deposits in the lower slope and riverine areas (Refer to Photo 1) is contrasted with the shallower upper slopes (Refer to Photo 2) and development of moderately deep and highly weathered materials on the mid and lower midslope positions (Refer to Photo 3), while significant areas of ferricrete platforms (Refer to Photo 4) were mapped.

Photo 1: Wet Based Soil

Photo 2: Shallow Structured on Gravel

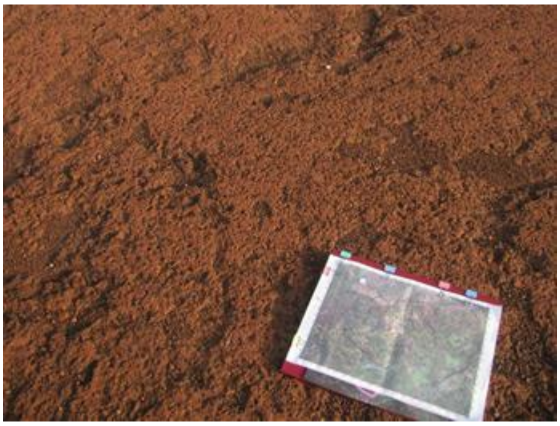


Photo 3: Deep Sandy Clay Loams **Photo 4: Ferricrete Pavements**

In contrast to the deeper and more friable materials are the shallow to very shallow rooted laterite pavements of hard plinthic/laterite soil forms, accumulations of iron and magnesium precipitates.

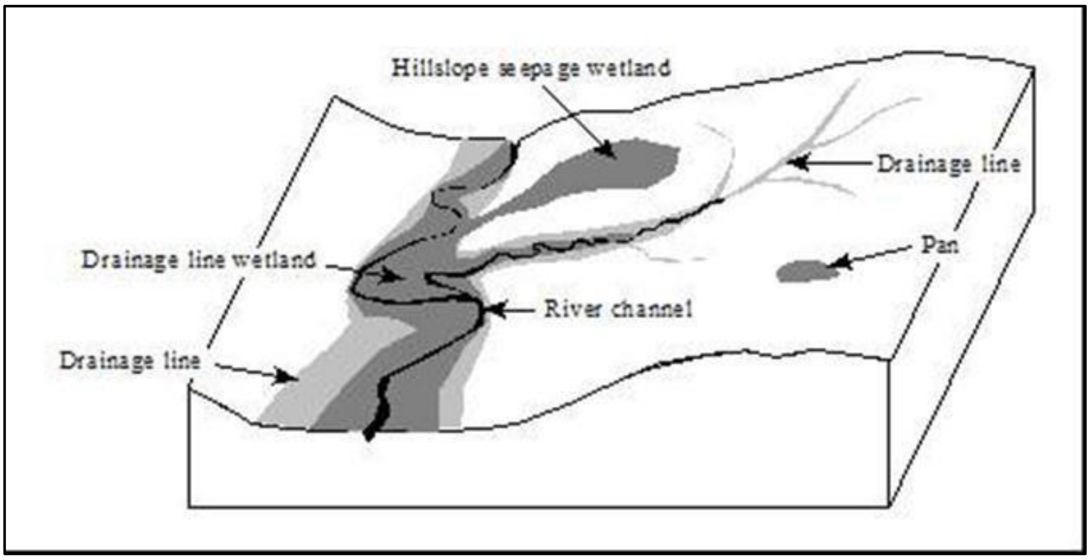
The degree of ferricrete or hard plinthite development is a feature that will be discussed in more detail as a function of ecological importance, its presence and position both within the landscape as well as within the soil profile being of importance to the ecological sensitivities and the resultant impact significance.

The retention of soil water within the vadose zone (lack of preferred horizontal flow) as a result of the hard plinthite development has resulted in the creation of inhibiting layers (ferricrete/laterite) within some of the soil profile and the development of wetness features at or close to surface. These features are generally associated with the lower lying areas and riverine/stream sites in terms of wetness and soil sensitivity, and occur within a particular lithological (geology) unit. Large areas also occur on mid and lower midslope positions within these units that show relic wetland features/land forms but are not necessarily still part of the active wetland environment. One of the goals of the study was to determine the presence of wetland soils within the Project area.

In general wetlands or soils associated with low chroma background colours with mottling and wetness at or close to surface are considered sensitive landscapes and as such, these areas have been singled out for management and possibly different mitigation in terms of the soil utilisation plan for the Project. Figure 3.1 shows a schematic of the different wetland types classified.

The relic land forms are commonly associated with hillside seeps and “sponge zones” both of which are associated with possible wet soil development. These features are important to the ecological and biodiversity cycle as they form the all-important near surface water holding reservoirs that contribute to the base flow of streams and rivers and sustain the soil water at and close to surface.

Figure 3.1: Schematic of the Wet Lands and their Relation to Topography (Wetland Consulting Services 2003)



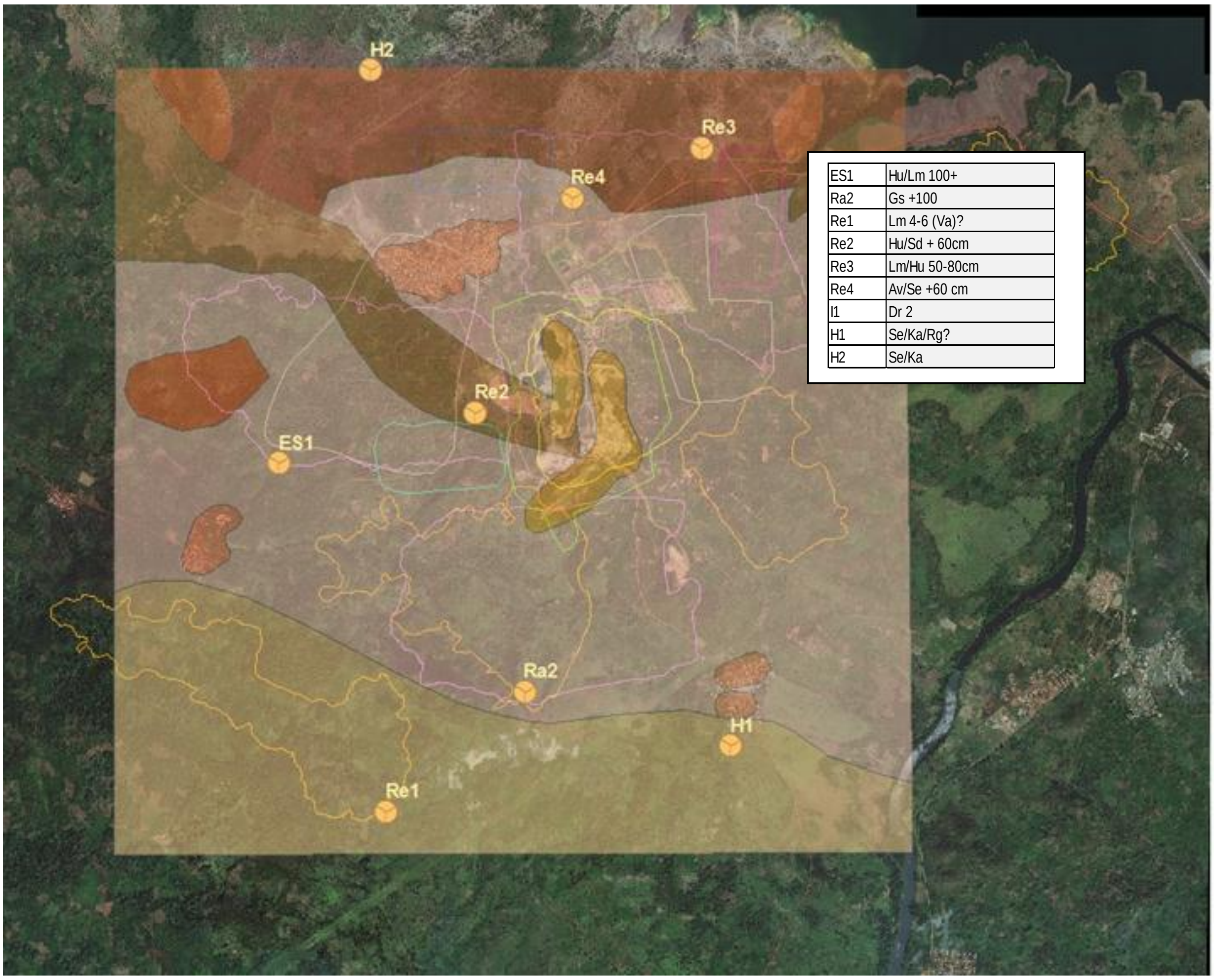
These sites are regarded as sensitive to highly sensitive and will require management inputs.

In addition, and as part of these sensitive systems, are the "transition zones" that contribute to the wetland catchment systems. These areas are also considered to be sites of moderate sensitivity.

The dominant soils in the Project area (Figure 3.3 – Dominant Soils Map) have been classified and are described in terms of their physical and chemical similarities and general geomorphology of the site, with input from the historical site assessment 2007 (Refer to Figure 3.2). The spatial distribution of the soils is of importance in the soil utilisation planning and management recommendations.

The soils mapped range from shallow sub-outcrop and outcrop of hard plinthite and parent materials (sediments and intrusive dolerite) to deep sandy loams and sandy clay loams on deeply weathering saprolite, with variations of moderately deep to shallow sandy loams and sandy clay loams that show variable structure, all of which are associated with either a rocky outcrop of sedimentary parent rock, or ferricrete/laterite "C" horizon at differing depths. The saprolitic horizons are generally quite thick, with deep lithocutanic and plinthic gravels occurring on hard bedrock at depth.

Figure 3.2: Historic Soils Mapping (2007 ESIA)



The soil groupings are described below, with reference to Figure 3.3. These include:

1. The deeper and more sandy loam soils are considered *High Potential* materials and are distinguished by the better than average depth (100cm to >150cm) of better drainage within the soil profile (80mm/m to 180mm/m).

   This group is recognisable by the complete lack of, or very subtle mottling (water within the profile for less than 30 % of the season – W1) at greater depths (>750mm on average), with a fine to medium grained texture, apedel to weak crumby structure and clays that range from as low as 12% to 18% in the top soil, and between 20% and 28% in the subsoil. These soils are generally founded on a ferricrete gravel or thick saprolitic layer.

   The land capability is rated as moderate intensity grazing land and/or moderate arable land capability depending on the nutrient and organic carbon stores and related production potential.

These soils are generally slightly lower in clay than the associated wet based soils and more structured and colluvial derived materials and have a distinctly weaker structure. The more sandy texture of this soil group renders them more easily worked and of a relatively lower sensitivity (depth >750mm).

2. In contrast, the *shallower* and often more *structured* materials are considered to be more *sensitive* and will require greater management if disturbed. This group (<500mm) is associated almost exclusively with the sub outcropping of the parent materials or shallow lithocutanic/saprolitic horizons. These materials are considered sensitive to moderately sensitive in terms of erosion, compaction and their workability and are associated with the more sensitive ecological sites. These sites have an important function in the sustainability of the overall biodiversity of an area with soil forming the natural rooting matrix for plant material, a consideration that is extremely important in the maintenance of vegetative cover and the minimisation of erosion, while protecting the water resources of an area.

   These areas will require management input if disturbed. These soils comprise fine to medium grained sandy clay loams for the most part, returned structure that is apedel to moderate blocky at the extreme, with clay contents that range from 18% in the upper horizons to as high as 35% where the soils are associated with a more basic geology (dolerite) or in areas of colluvial derived soil.

3. The third group of soils comprises those that are associated with the hard pan ferricrete layer and perched/confined soil water. This group of soils has a set of distinctive characteristics and nature that are separated out from the other soil groupings due to their inherently much more difficult management characteristics. These soils are characterised by relatively much higher clay contents (18% to 25% TS and as high as 60% in the SS - sometimes of a swelling nature – smectites), poor water intake rates, inhibited and poor drainage (60mm/m to 100mm/m) characteristics and the associated poor liberation of soil water to plants in the case of the more platy and swelling clays which bind the soil water.

   The more structured nature of these soils and the inherent wetness are restrictive on rooting depth, while the hard pan nature of the ferricrete is also an inhibiting factor and a barrier within the top 500mm to 750mm of the soil profile.
   These soils are generally associated with a *wet or saturated basal horizon,* and are considered to be sensitive to highly sensitive in nature, albeit that they are generally considered to be a "*relic"* land form.

   Large and significant area of well-developed ferricrete outcrop/sheet outcrop was mapped within the study area and laterite is common within the vadose zone.

   The development of wet based soils and moist grassland environments were mapped in association with these soil forms.

   Groundwater is understood to be relatively deep for the majority of the area of study and is considered to have little to no influence on the vadose/soil water.

These soils will be more difficult to work in the wet state and more difficult to store and re-instate at closure.

Again, it is noted as important to the baseline study, that these soil groupings are moderately extensive in spatial area, and cover a significantly large spatial area in terms of the proposed development plan (both mining and its infrastructure encroach).

Additional management inputs and mitigation will be recommended for areas that rate as highly sensitive or valuable in terms of the soil and land capability.

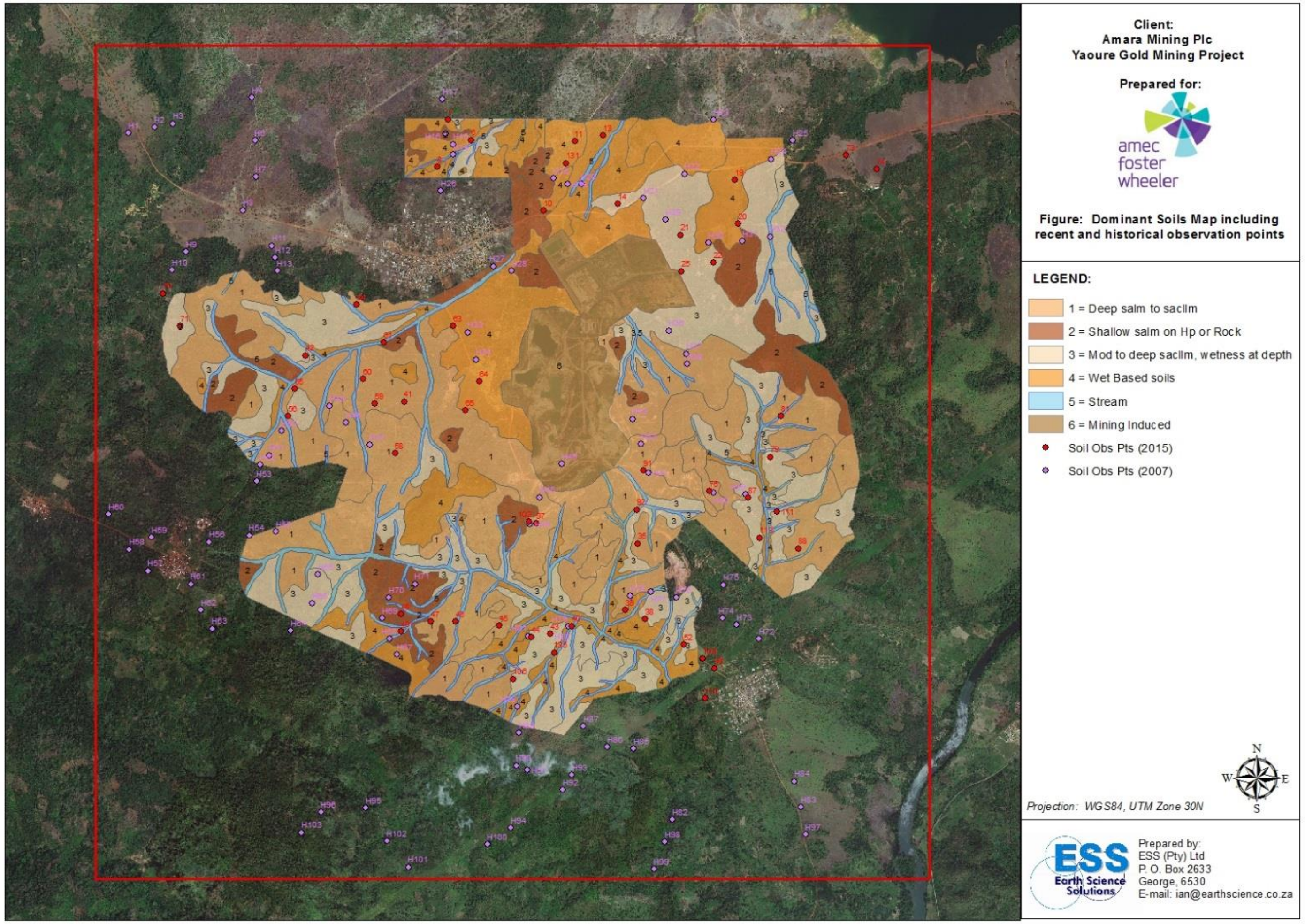
4. In addition, and separated from the wet based structured soils are the group of soils that reflect *wetness* within the top 500mm. These soils are easily recognised by the mottled red and yellow colours on low chroma background to the soil. These soils are regarded as *highly sensitive* zones that will require management inputs if disturbed (Refer to Figure 3.4 – Site Sensitivity Plan).

   The concentrations of natural salts and stores of nutrients within these soils are again a sensitive balance due to the extremes of rainfall (excessive leaching) and temperature, with leaching evident in the low chroma colours. The ability of a soil to retain moisture and nutrients, and in turn influence the sustainability of vegetative growth and dependence of animal life is determined by the consistency and degree of soil moisture retention within the profile but out of the influence of evaporation.

   These conditions and associated sensitivities should be noted in terms of the overall bio-diversity balance if the sustainability equation is to be managed and mitigation engineered.

All areas included in the study have been captured in a GIS format and mapped according to the soil classification nomenclature and soil depth (decimetres), while the similar soil forms have been grouped and mapped as dominant groupings for ease of management (Figure 3.3).

Figure 3.3: Dominant Soils Map



When considering the sensitivity of a soil, the depth to an inhibiting layer and the amount of redox reaction present (noted in the degree of mottling and more importantly the greyness of the soil matrix) within the profile dictates the degree of wetness in terms of the "wetland delineation classification" and will have an effect on the ecological sensitivity of the site.

The shallow to very shallow soil profiles are generally associated with an inhibiting layer at or close to surface, and as already alluded to, is the defining feature that controls the ability (or not) of water to flow vertically down and through the profile (restrictive layer).

The degree to which the plinthite layer has been cemented (friability of the ferricrete) will determine the effectiveness of the layer as a barrier to infiltration, while the depth of overlying soil will dictate how easily or difficult it is for the soil water to be accessed by the fauna and flora, and in the extreme case weather water is held at surface as a pan. The friability of the ferricrete will also have an effect on the amount of clay mineralisation that the soil contains within this horizon, and will in turn influence the water holding characteristics of the soil and the degree of structure of the material above the ferruginous layer.

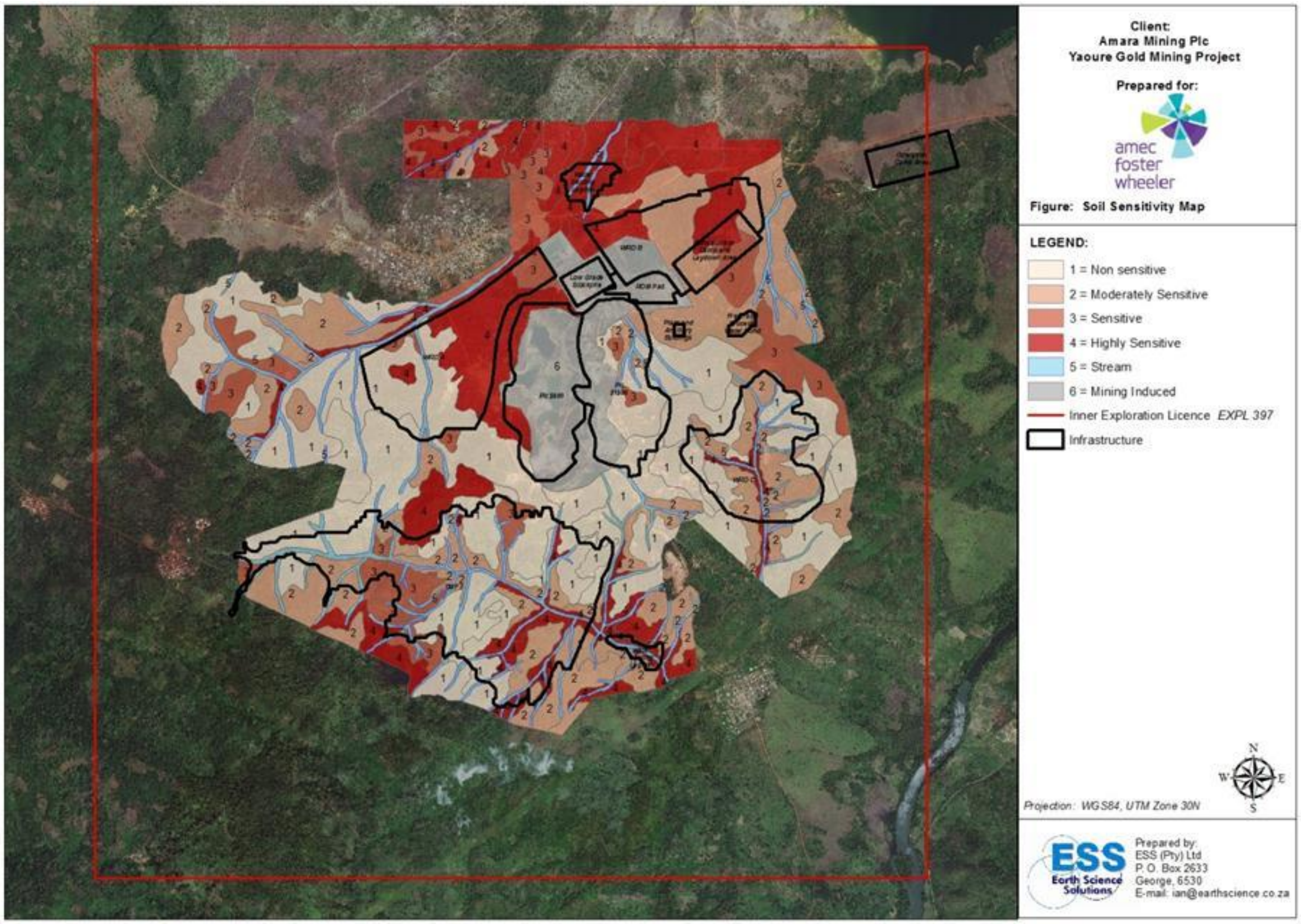
In addition to the soil system of classification, a system has been developed for the describing and classification of ferricrete. This system has been used in better understanding the land forms that result from their presence (Refer to Appendix 1).

In contrast, the deeper and more sandy profiles have a distinctly differing pedogenetic processes that are associated with lower clay contents, better drainage of the soils and a deeper weathering profile. The degree of iron formation is less, with the percentage of base metals considered the primary driver. Iron rich/ferruginous gravels were noted at the base of many of these profiles.

As with any natural system, the transition from one system to another is often complex with multiple facets and variations over relatively small/short distances, something that is particularly pertinent to this particular area as the attitude of the lithological units is inclined at varying degrees of dip.

With these considerations and variables assessed, the relative sensitivity of the site was mapped. Figure 3.4 depicts the spatial distribution and relative sensitivities (non sensitive, moderately sensitive, sensitive and highly sensitive) of the study area.

Figure 3.4: Site Sensitivity Map



3.1.2 Soil Chemical and Physical Characteristics

A suite of representative samples from the differing soil forms were taken and sent for analyses for both chemical and physical parameters, refer to Table 3.1 – Analytical results). A select number of samples (10) were submitted, each sample containing a number of sub samples from a particular soil Form which is representative of the area in question. Each sample comprises a "composite sample", and is representative of the Soil Form rather than a specific point sampled.

3.1.2.1 Soil Chemical Characteristics

Sampling of the soils for nutrient status was confined where possible to areas of undisturbed land (see sampling points included in Figure 3.3 and Table 3.1).

However, some of the better soil exposure is associated with land that has or could have been disturbed by artisanal mining and/or farming activities. These results are representative indications of the pre-construction conditions, and are at best an indication of the baseline conditions. These results will need to be verified for particular sites as and when rehabilitation is being considered and/or planned.

The results of the laboratory analysis returned a suite of results, a reflection of both the differences in the chemistry of the differing geologies/lithologies from which the soils are derived as well as the influence of climate, soil movement and the leaching of the soil nutrients over time.

The analytical results reflect a variety of differing source materials that range from very well sorted sandy loams with lower than average nutrient stores and moderate clay percentages (12% to 18% - B2/1 horizon), to soils with a moderately stratified to moderate blocky (pedocutanic) structure, sandy loam to sandy clay loam texture and varying degrees of utilisable nutrients. These soils are generally confined to the colluvial derived materials that returned higher than average clays (+25%), and highly variable structure (weak blocky to prismacutanic and gleycutanic). These soils are confined almost exclusively to the wet based and wetland soils associated with the alluvial/colluvial derived and bottom land floodplain wetlands.

In general, the pH ranges from weakly acid at 5.1 to slightly more neutral at 6.5, base status ranging from 6.5me% to 18me% Mesotrophic (moderate leaching status) to Dystrophic (highly leached)], and nutrient levels reflecting generally moderate to high levels of calcium and magnesium, acceptable Ca/Mg ratios (3:1), and moderate to good levels of sodium and potassium. The Phosphate levels are generally high, with areas of very high and possibly toxic aluminium. The levels of iron and zinc are also high and evident in the sheet ferricrete. The metals were assessed as part of understanding the baseline values that exist, and so that management of impacts can be gauged once the mining and processing starts.

The soil distribution and its associated chemistry is linked to a great extent to the geology from which it is derived, and as such, the changes occur over relatively small spatial distances due to the attitude of the lithological units. This makes for some difficulty in describing the effects of soil chemistry on the environment when using a reconnaissance grid base. However, there is sufficient information available for generalised patterns to be drawn, and for the effects of the soil nutrients to be gauged against the possible impacts that will be imposed by the Project.

The relationship between geology and soil chemistry is not as strong in the lower lying areas and floodplains of the river systems where the soils are of a colluvial or alluvial origin, and the effects of having been transported over distance has masked any input of the geology. The chemical signature on these materials is far more variable, with the effects of leaching quite apparent.

Sites with elevated aluminium, zinc/iron and Phosphate are not generally conducive to the cultivation of cereals and vegetables. Cassava and the natural vegetation (indigenous bush) found in these tropical environments have adapted to the chemistry of these soils, but little of commercial value will grow naturally in these conditions.

3.1.2.2 Soil Fertility

The soils mapped returned moderate levels of some of the essential nutrients required for plant growth with sufficient stores of sodium, potassium and phosphates (excessive), and adequate concentrations of calcium and magnesium. The levels of Al and P associated with some of the soils (generally associated with the more basic derived (geologically) materials) are considered restrictive to many plants' growth, and as such, the potential for the cultivation of commercially viable food schemes is considered negative.

However, the deep sandy loams and most of the colluvial/alluvial derived soils associated with the larger streams and floodplain deposits hold some potential for commercial agriculture, with better than average organic carbon and sufficient water holding capability on well drained materials.

These areas will need to be assessed in more detail if consideration is given to planning any community schemes.

Table 3.1: Analytical Results

Ref: JOB 2014-A-338

Soil Standard Analysis

Lab Sample No	Sample No	Dom Soil Gp	Soil Fm	pH(water)	Res(ohms)	Ca mg/kg	Mg mg/kg	K mg/kg	Na mg/kg	P (Bray1)	Al mg/kg	Ca/Mg	Ca+Mg/K	CEC
4255	Y41	1	Hu/Sd	5.31	750	2071	525	122	10	8.4	21	3.95	21.28	15.25
4256	Y42	2	Tk/Va	5.61	700	2196	619	88	9	8.8	25	3.55	31.99	16.6
4257	Y92	2	Tk/Cv	5.62	1200	1363	404	58	2	8.2	21	3.37	30.47	10.52
4258	Y135	4	Se	5.68	800	1875	322	130	11	8.6	30	5.82	16.9	12.73
4259	Y91	2	Oa	5.15	1100	917	288	74	8	8.7	8	3.18	16.28	7.26
4260	Y000	3	Tk	6.03	410	2408	750	132	22	10.2	6	3.21	23.92	18.69
4261	Y131	4	Lo	6.19	2100	819	331	48	13	9.7	9	2.47	23.96	7.09
4262	Y111	3	Tk/Pn	6.01	430	2653	768	192	12	10.6	6	3.45	17.82	20.17
4263	Y115	4	Pn	6.53	440	3518	942	116	42	10.9	7	3.74	38.45	25.87
4264	Y113	3	Tk/Gc	6.37	510	2424	862	174	12	11.9	8	2.81	18.89	19.77

Soil Micro-Elecment & Physical Analysis

Sample No	Sample No	Dom Soil Gp	Soil Fm	Zn mg/kg	Fe mg/kg	C %	Org Mat %	Sand %	Silt %	Clay %
4255	Y41	1	Hu/Sd	1.51	85.8	2.24	3.85	54	19	27
4256	Y42	2	Tk/Va	1.63	96.8	1.92	3.3	46	17	37
4257	Y92	2	Tk/Cv	1.53	33.1	0.48	0.83	58	17	25
4258	Y135	4	Se	6.14	64.7	1.28	2.2	64	11	25
4259	Y91	2	Oa	1.27	34.9	1.28	2.2	54	17	29
4260	Y000	3	Tk	2.17	67.1	2.24	3.85	68	11	21
4261	Y131	4	Lo	1.17	79.3	1.36	2.34	54	19	27
4262	Y111	3	Tk/Pn	2.9	64.4	2.64	4.54	84	3	13
4263	Y115	4	Pn	1.42	40	2.16	3.72	64	13	23
4264	Y113	3	Tk/Gc	0.86	90.9	0.88	1.51	84	3	13

3.1.2.3 Nutrient Storage and Cation Exchange Capacity (CEC)

The potential for a soil to retain and supply nutrients can be assessed by measuring the cation exchange capacity (CEC) of the soils.

The inherently moderate organic carbon content is advantageous to the exchange mechanisms, as it is these elements which naturally provide exchange sites that serve as nutrient stores. The moderate clay contents will temper this situation somewhat with at best a moderate retention and supply of nutrients for plant growth.

Low CEC values are an indication of soils lacking organic matter and clay minerals. Typically a soil rich in humus will have a CEC of 300 me/100g (>30 me/%), while a soil low in organic matter and clay may have a CEC of 1-5 me/100g (<5 me/%).

Generally, the CEC values for the soils mapped in the area are moderate to good, with all but the alluvial and deep colluvial materials returning adequate values for positive plant growth. This is ascribed to the lower than average organic carbon and lower clay contents.

3.1.2.4 Soil Physical Characteristics

The majority of the soils mapped exhibit apedal to weak crumby structure, moderate to high clay content and a dystrophic leaching status. The texture comprises sandy loams or sandy clays and clay loams for the most part, with much finer silty loams and clay loams associated with the colluvial and alluvial derived materials mapped in the lower slope and bottom land stream and river environs. Table 3.1 reflects the relative physical parameters for the major soil forms mapped).

Of significance to this study, and a feature that is common across large portions of the site where the deep weathering of the soils (up to 10m recorded in drill cores) a function of the geology and the high rainfall. However, this is contrasted by the very shallow and sheet form ferricrete “banks” noted on the more basic iron rich lithologies.

The presence of the laterite of ferricrete layers are associated with the more flat dipping iron and magnesium rich sedimentary host rocks (albeit that it often occurs below the 1.5m auger depth on the deeper soils) and the climatic conditions, all conducive for the formation of evaporites. The tropical climate (positive water balance) combined with the geochemistry of the host rock geology are conducive to the formation of iron ferricrete and the development of ferruginous layers or zones within the vadose zone. This process results in the development of a restrictive or inhibiting layer/zone within the profile over time.

The degree of hardness of the evaporite is gradational, with soft plinthic horizons (very friable and easily dug with a spade or shovel), through hard plinthite soil (varying in particle size from sand to gravel – but no cementation) to nodular and hard pan ferricrete or hard plinthic (cementation of iron and manganese into nodules) that are not possible to free dig or brake with a shovel.

This classification is taken from -Petrological and Geochemical Classification of Laterites - *Yves Tardy, Jean-Lou, Novikoff and Claude Roquid (1991),* and forms the basis for classify the hard pan ferricrete or lateritic portion of the soil horizon in terms of its workability (engineering properties) and storage sensitivities.

The soil classification system takes cognisance of ferricrete and has specific nomenclature for these occurrences. The variation in the consistency of this layer, its thickness and extent of influence across/under the site are all important to the concept of a restrictive horizon or barrier layer that is formed at the base of the soil profile and/or close to the soil surface.

Where this horizon develops to a nodular form or harder (Nodular, Honeycomb and Hard Pan) the movement of water within the soil profile is restricted from vertical movement and is forced to move laterally or perch within the profile. It is this accumulation of soil water and the precipitation of the metals from the metal and salt rich water that adds progressively to the ferricrete layer over time. This situation will be very difficult to emulate or recreate if impacted or destroyed.

Important to an understanding of the development of the ferricrete is the geological time and presence of the specific soil and water chemistry under which the horizon forms.

Destruction of this impeding layer due to mining or related activities will result in the loss of soil moisture down the profile and the potential for dirty water ingress and the inability for the fauna and flora to access the soil moisture as readily.

3.1.2.5 Soil Erosion and Compaction

Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of a particular soil as well as the treatment of the soil.

The resistance to, or ease of erosion of a soil is expressed by an erodibility factor ("K"), which is determined from soil texture/clay content, permeability, organic matter content and soil structure. The Soil Erodibility Nomograph (*Wischmeier et al.,* 1971) was used to calculate the "K" value.

With the "K" value in hand, the index of erosion (I.O.E.) for a soil can then be determined by multiplying the "K" value by the "slope %" (measured as a percentage). Erosion problems may be experienced when the Index of Erosion (I.O.E) is greater than 2.

The majority of the soils mapped can be classified as having a moderate to high erodibility index in terms of the slope %, and a moderate to low erodibility index in terms of the organic carbon content and clay content.

However, the vulnerability of the "B" horizon to erosion once the topsoil and/or vegetation is removed must not be underestimated when working with or on these soils. These horizons (B2/1) are vulnerable and rate as medium to high when exposed, with the high rainfall and storm intensities playing a major factor in the erosion of unprotected materials, if they are temporarily exposed during construction or operations.

The concerns around erosion and inter alia compaction, are directly related to the disturbance of the protective vegetation cover and topsoil that will be disturbed during any construction and operational phases of the mining venture. Once disturbed, the effects and actions of wind and water are increased.

Loss of soil (topsoil and subsoil) is extremely costly to any operation, and is generally only evident at closure or when rehabilitation operations are compromised, but play an ever increasing role in the water quality and utilisation potential of streams and rivers that are of primary concern to many of the rural communities encountered in and around mining projects. The impact on domestic drinking water can have devastating and long lasting effects on communities. In order to minimise impacts on this valuable resource, soil conservation and protection measures are described in the Soil Management Plan.

Well planned management actions during the pre-feasibility and feasibility phases, will have a significant financial and social effect through the construction and operational phases, and will save time and money in the long run, and will have an impact on the ability to successfully "close" an operation once completed.

3.2 Pre-Construction Land Capability

3.2.1 Data Collection

Based on a well-developed and scientifically founded baseline of information, the Canadian Land Inventory and Land Capability Rating System has been utilised as the basis for the land capability study.

Using this system the land capability of the study area was classified into four distinctly different and recognisable classes. These include an arable land capability rating, a grazing land capability rating, a wilderness or conservation land capability rating, and a wetland or wet based soils rating. The criteria for this classification are set out in Table 3.2 below.

Table 3.2: Criteria for Pre-Construction Land Capability (Canadian Land Inventory and Land Capability System)

Criteria for Wetland	• Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water dependent.
Criteria for Arable land	• Land, which does not qualify as a wetland. • The soil is readily permeable to a depth of 750 mm. • The soil has a pH value of between 4.0 and 8.4. • The soil has a low salinity and Sodium Absorption Ratio (SAR) • The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100 mm in the upper 750 mm. • Has a slope (in %) and erodibility factor (K) such that their product is <2.0 • Occurs under a climate of crop yields that are at least equal to the current national average for these crops.
Criteria for Grazing land	• Land, which does not qualify as wetland or arable land. • Has soil, or soil-like material, permeable to roots of native plants, that is more than 250 mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100 mm. • Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.
Criteria for Wilderness land	• Land, which does not qualify as wetland, arable land or grazing land.

3.2.2 Description of Findings

The “land capability classification” as described in Table 3.2 was used to characterise and classify the dominant units of land identified during the pedological survey.

These criteria combined the specialist soils information with the geomorphological aspects (ground roughness, topography, climate etc.) of the site in obtaining a rating for the capability of the land in question.

The area to be disturbed by the open cast mining and surface infrastructure development comprises a range of land capability classes, with significant areas of friable and good grazing potential class soil, smaller but highly sensitive sites that returned wet based soils, and a significant area of highly structured and sensitive materials that occur within the planned development footprint.

Table 3.3 reflects the relative area of each land capability rating class. A relatively small but significant area of potentially arable land was also considered and mapped, albeit that aluminium and metal toxicity are noted as problems for many of the food crops. Any sites considered for agricultural/commercial planting should be assessed in more detail prior to the planning or implementation of any development.

Table 3.3: Land Capability as a Percentage of Study Area

Land Capability Rating	Area (Ha)	% Of area
1 = Arable	520.6200	26.35%
2 = Grazing	605.7083	30.66%
3 = Wilderness	168.8549	8.55%
4 = Wet Based	385.3178	19.50%
5 = Stream	120.5016	6.10%
6 = Man Induced	174.6321	8.84%
Total Area	*1 975.6347*	100.00%

The soils with high aluminium values (toxic elements) are considered at best to have a low intensity “natural” grazing land potential or more readily a wilderness status for the most part, with the soil chemistry and to some extent the geomorphology (slope, attitude and ground roughness) discounting the deeper and better structured soils from an arable potential rating. It is the ability of the soils to meet the crop yields, a function of the “current national average” for any particular crop that leaves the soils confined to grazing and conservation status.

This should not be confused with “land use”, which is often different from its actual “capability”, and with additives and or the low yield requirements of subsistence farming renders many soils as “utilisable” in the circumstances.

The proposed open pit workings and associated infrastructure cover the full suite of soil sensitivities and land capability, with a significantly large spatial area of the highly sensitive wetland soil ratings associated with the rivers and associated transition zone wet based soils, sensitive to moderately sensitive sandy loams and sandy clay loams associated with the middle and upper midslope positions and the more sensitive to high sensitivity shallow soils associated with the ridge slopes and erosive environment.

Figure 3.5 illustrates the distribution of land capability classes across the study area, while Table 3.3 reflects the relative area of for the ratings.

3.2.2.1 Arable Land

There are limited (~ 26%) areas of arable potential soils associated with this area, notwithstanding the fact that large areas return soils depths that are reflective of a arable status (>750mm), the growth potential (nutrient status and soil water capabilities) and ability of these soils to return a cropping yield equal to or better than the national average is lacking. This is due mainly to the soil chemistry, the steepness of the terrain and to some extent the nutrient status. These variables reflect the natural conditions, and do not include any man induced additives such as fertilizers or water. Impacts of existing land use (artisanal mining and farming) will also influence the overall area of arable potential.

3.2.2.2 Grazing Land

The classification of grazing land is generally confined to the shallower and transitional zones that are well drained. These soils are generally darker in colour, and are not always free draining to a depth of 750mm but are capable of sustaining palatable plant species on a sustainable basis, especially since only the subsoil's (at a depth of >500 mm) are periodically wetted. The classification also makes allowances for the fact that the deeper soils are able to sustain the natural vegetation and plant growth, most of which is palatable to wildlife and domestic livestock.

A significant area (31%) of the study area classifies as low intensity grazing land or wilderness status.

3.2.2.3 Wilderness/Conservation Land

The shallow rocky areas and soils with a structure stronger than strong blocky (vertic etc.), or shallow soil on a lithocutanic base are characteristically poorly rooted and support at best very low intensity grazing, or more realistically are of a wilderness character and rating. This land capability rating accounts for approximately 8% by area.

3.2.2.4 Wet Based Soils/Wetland (Areas with wetland status soils)

Wetland areas in this document (soils and land capability) are defined in terms of the wetland delineation guidelines as defined in the IFC PS 6 and the Wetland and Riparian Delineation

Guidelines 2008 (DWA 2008) and the Guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed, which use both soil characteristics, the topography as well as floral and faunal criteria to define the domain limits. Only the soils are described here, and as such the term wet based soils is used and not "wetlands."

These zones (wetlands) are dominated by hydromorphic soils (wet based) that often show signs of structure, and have plant life (vegetation) that is associated with seasonal wetting or permanent wetting of the soil profile.

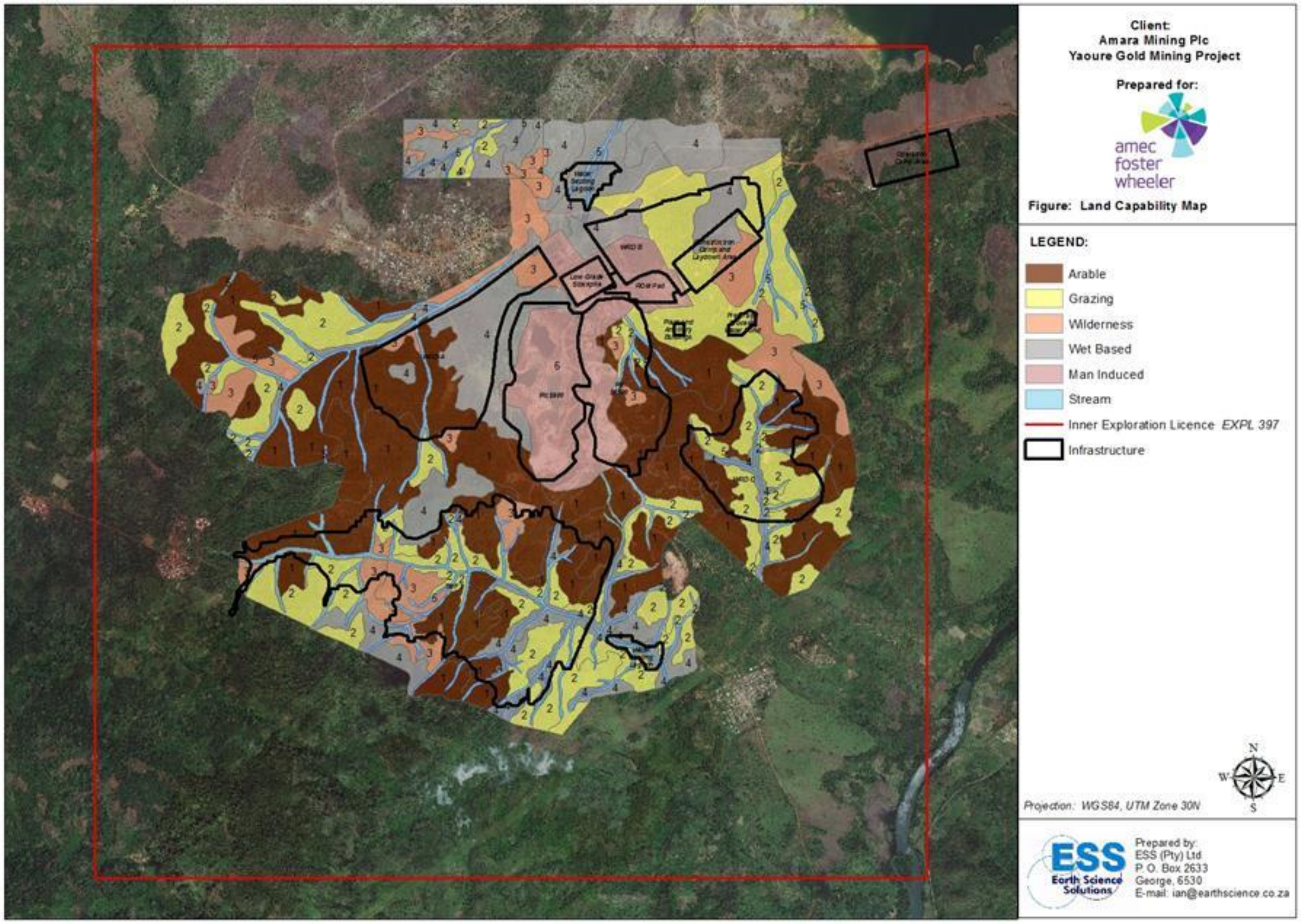
The wetland soils are generally characterised by dark grey to black (organic carbon) in the topsoil horizons and are often high in transported clays and show variegated signs of mottling on gleyed backgrounds (pale grey colours) in the subsoil's. Wetland soils occur within the zone of soil water influence.

A significant proportion (19%) of the study area classifies as having wet based soils. It is important to note that a significantly large area of the open pit and infrastructure development being planned encroaches on soils with a wet base classification.

These **should not be** mistaken as wetlands in terms of the delineation system, but should be highlighted as potential zones of sensitivity with the potential for highly sensitive areas associated with the prominent waterway that cross cut the proposed development.

These zones are considered **very important, highly sensitive and vulnerable** due to their ability to contain and hold water for periods through the summers and into the dry winter seasons.

Figure 3.5: Land Capability Map



3.3 Land Use

3.3.1 Land-Use Typology

This section should be read in conjunction with the specialist report that gives the detailed findings and illustrations – Land Use Map of Yaoure Gold Project – 2D Consulting Afrique (March 2015).

The results of the land use study concluded that there are several habitat types that occur within the study area and that have been identified as important to the study area.

These include degraded forests or riparian secondary forest and galleries, perennial crops, intercropping or annual crops from Lake Kossou, the Bandama River, villages and hamlets, open surfaces, roads and tracks, high voltage lines, artisanal mining activities, mining activities and wetlands. The definition of some would be essential to the correct reading of the map.

Degraded or secondary forests are primary forests which have been altered beyond the normal effects of natural processes and are classified either as degraded primary forest, secondary forest or degraded woodlands. Thus, will be considered as degraded forest, primary forest whose original cover has been affected by unsustainable exploitation of wood and NTFPs[1] which cause that its structure, its processes, its functions and its dynamics are altered at the point of compromising the ability to adapt in the short or medium term of ecosystem. On the other hand, the secondary forest is a woody vegetation restored on land which the original forest cover has been largely cleared (at least at 90%). In general, secondary forests grow naturally on land abandoned after shifting agriculture, sedentary agriculture, pasture, or tree plantations failure (FAO, 2002; OIBT, 2005).

In our study, secondary forests and degraded forest are the same entity. Because even though regarding their definition, these two formations differ in their origin, they become very close in their structure.

Riparian forests are specific forest formations which are associated with rivers. These formations are located in ecological transitions between aquatic habitats and land areas. The riparian forests are subject to frequent flooding. Unlike riparian forests, Gallery forests are characterized by their joined canopy above a River or stream, or a wetland area of which the presence of water may be temporary. In this study based on the analysis of the GeoEyes image, the main feature for the identification of the riparian forests and galleries was its proximity to the river Bandama.

Savannahs include a number of sub sets. These include, areas with predominantly grass cover, defined as a carpet of large grass forbs measuring at least 80cm in height at the end of the growing season, with associated smaller weeds and grasses (Yangambi, 1956 and Letouzey, 1982). These areas are usually burned each year.

[1] NTFP : "goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests"

In addition to these grassy areas, there are areas with more trees and shrubs that form a light shade over the grass bed, and a "shrubby" Savannah that comprises only shrubs on the grassy carpet (trees are absent). These three savannah types occur in distinctive topographic settings and/or as a result of disturbance by human activity.

Annual Cropping and Associated agriculture are noted as other activities in terms of land use that occur on the study area. These activities are important in terms of the eco system services as well as subsistence to the local people, while **artisanal mining** is part of the reason why people have inhabited the area.

Farming activities noted include:

- The production of perennial crops which comprise cultivars of woody plants (trees, shrubs) that produce a crop on an annual cycle. These comprise Cocoa orchards/plots that have been cultivated and maintained over several years; and
- Annual crops which form an important part of the farming activities comprise a mixture of cultivated foods including cassava, taro and plantains.

An important point to note when discussing annual cropping is the system of rotational farming that is practised. The effects are often confused with the open field effects noted on the satellite imagery that are associated with the summer fallow.

Fallows are plots of land which could produce but are temporarily left unplanted for one or two years so that the soils can rejuvenate (Duhamel du Monceau, 1758; Robinson, 1962). The majority of the farming activities occur in close proximity to the villages and inhabited areas around Angovia, Allahu Bazi, Kouakougnanou, Akakro, Da Koffi Yobouekro and Bokasso.

The wetland are defined as areas of marsh, fen, peat land or natural or artificial water, permanent or temporary, where the water is stagnant or flowing, fresh, brackish or salty, including areas of marine tidal water with depths of less than six (6) metres (Ramsar Convention, 1971). Wetlands in the study area are confined almost exclusively to the floodplains of Lake Kossou and an area in the south central sector of the site were two secondary streams converge. Wet based soils are noted throughout the area confined mainly to the numerous streams and non-perennial waterways, with many of the bottomlands/stream sections (generally less than 30m wide) returning wetness within the top 500mm of the soil profile. These characterise wetland environments (Refer to Figure 3.5 – Land Capability Map).

Lake Kossou is used for the production of electricity, and is built on the River Bandama. It is one of the major rivers of Côte d'Ivoire. **High voltage electrical lines** are used to transmit the electric power off site.

These are prominent infrastructure in the area.

Generally, these high-voltage lines are rights-of-way areas which are maintained (cleaned). This situation gives rise to dense herbaceous vegetation but without wood.

Significant areas of bare soil where also noted and mapped. These comprise roads and tracks, quarries and artisanal workings, land cleared for the preparation of crops, or simply land denuded by the drought in the grassland and shrub land savannahs.

3.3.2 Land-Use Mapping

The study area covers an area of 11, 513.85 ha (Table 3.3), which is a square of about 12km by 10km. Table 3.4 of the areas occupation indicate that savannahs occupy approximately 53% of the Project area, forests approximately 30%, crops (perennial and annual) about 13% and only 1% for bare floors. It should also be noted that the open surface area is to be taken with extreme caution.

Table 3.4: Spatial Distribution of the Different Land-use Types

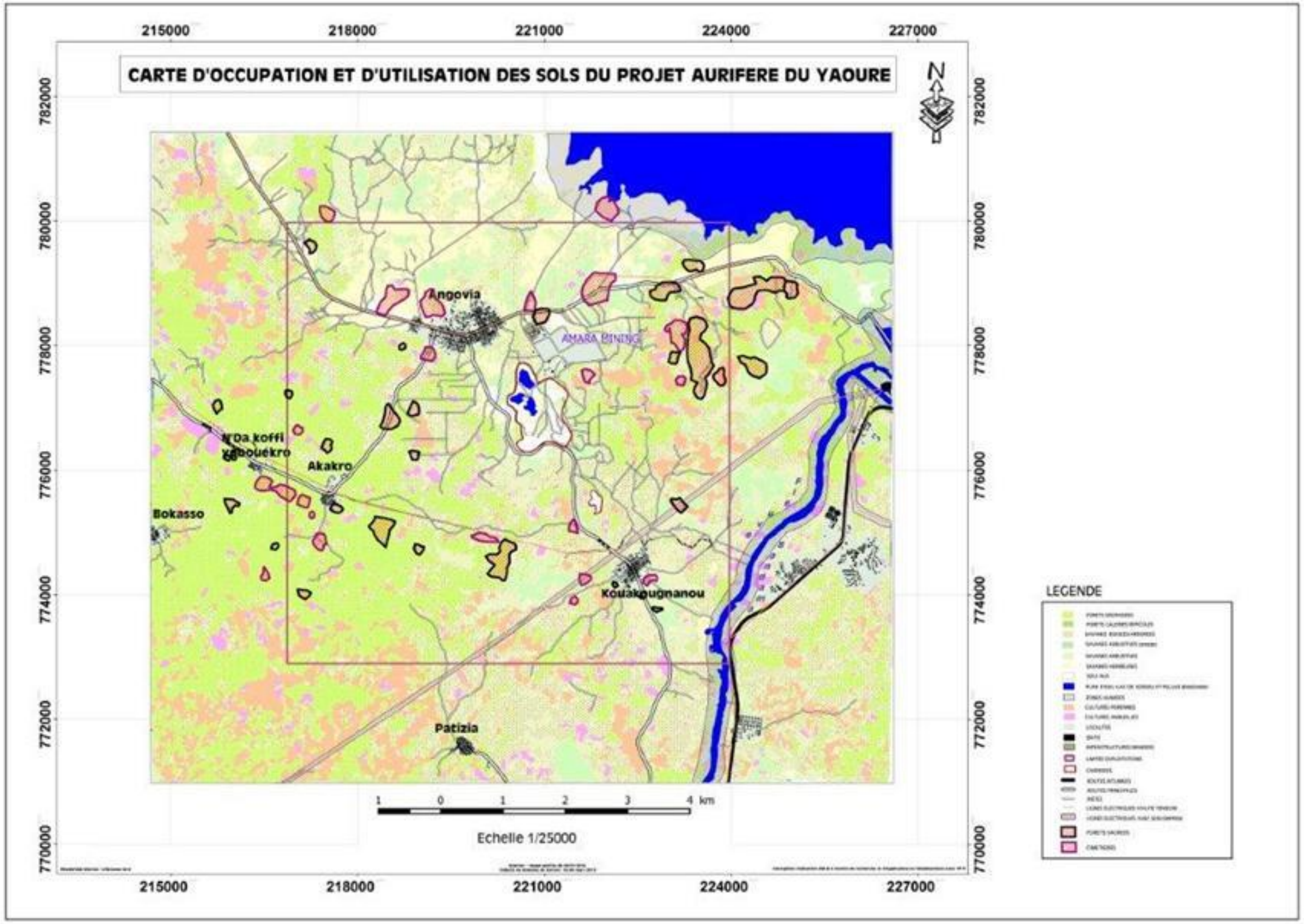
	Surface (ha)	Percentage	
Perennial cultures	1,269.34	11.0	13.6
Annual cultures	300.75	2.6	
Localities	174.16	1.5	1.5
Bare soils	112.53	1.0	1.0
Waters	41.24	0.4	0.4
Grass lands	721.28	06.3	53.4
Bush lands	1,910.12	16.6	
Dense bush lands	865.92	7.5	
Wooded savannahs	2,651.52	23.0	
Degraded/riparian/gallery forests	3,467.00	30.1	30.1
Total	11,513.85	100	100

The outcomes of the study are considered accurate, albeit that the data will vary depending on the seasons. Indeed, the basic image of this study is dated from the dry period (January 4, 2014) where fires, land preparation with crops, as well as gold panning activities contributed to maximize their scope. Another important remark, is the lack of primary forests, i.e. a forest not yet affected by human activities. Indeed, even if it is initially a mosaic of savannahs and dense semi-deciduous forests area, traces of human activities (operations) were noted in all of the visited forests. Thus, they have a fairly degraded physiognomy.

Regarding agricultural land it is, sometimes difficult to identify and therefore their spectral discrimination was offset by a manual interpretation/digitalization.

It is, however, not excluded that some farms escaped to this combination of methods for extracting information from space images (image classification and digitalization of information by visual interpretation). Indeed, this case is very likely, especially for cocoa-growing under (forest) cover. Another possible mutation to report is the conversion on the one hand very important annual crops within a few years in perennial crops. Indeed, food crops are largely associated crops, i.e. perennial crops at a juvenile stage, and covered by subsistence crops.

Table 3.5: Land Use Map



3.3.3 Conclusion

In conclusion:

- Spatial data processing (Image GeoEyes of January 2014) completed and validated by field data collection (10 days) helped achieve the main objective of this study, which was to improve knowledge on the land use and habitat types in the Project area by the production of a map;
- A land use map was developed with various cartographic units whose surfaces are estimated. The different cartographic units are as follows:
  - Degraded/secondary forests and wooded savannahs
  - Galleries / riparian forests
  - Dense bush land
  - Bush land
  - Grassland
  - Wetlands
  - Perennial crops
  - Annual crops (intercropping) / fallow)
  - Open surfaces
  - Villages and hamlets
  - Quarries
  - Roads and tracks
  - High voltage line
  - River Bandama
  - Lake Kossou
  - Artisanal Mine (quarries)
  - Mining infrastructure.

3.4 Summary and Conclusions

The baseline has highlighted hydromorphic soils and the shallow ferricrete based materials as areas of high sensitivity and of concern in terms of both management (workability) as well as the contribution that these soils make to the biodiversity and the ecological importance in the area.

The open cast mining operations and related infrastructural construction and operation footprint will impact on some of the hydromorphic environments identified, with the haulage ways and all access routes likely to traverse the full range of soil forms identified.

These issues have been dealt with in more detail as part of the impact assessment.

The sensitive sites (predominantly stream, water ways and river crossings) will need to be discussed in more detail with the flora specialist and hydrologist as part of the final design planning. Only with the inputs of the related earth sciences will a full understanding and more in-depth comprehension of these issues be obtained.

4.0 ALTERNATIVES ASSESSMENT – TMF

Of consequence to any sustainability equation is the consideration of the soil resource, and the concept of "No Net Loss", and although it is understood that this is seldom attainable for a development such as an Open Cast mining operation with all of the associated infrastructure, the concept is a good one and should be considered as a best practice limit to be aimed for wherever possible.

It is also important that the site sensitivities and baseline information is utilised to its maximum in positioning the infrastructure away from the more sensitive sites and on areas that are easier to manage and mitigate.

Yaoure has seen changes to the development plan through the feasibility and planning phases, with the optimisation of the infrastructural sites based on the social, economic and environmental aspects. The soils and land capability are but two of these aspects that are used, while the positioning of the TMF needed some additional inputs as part of the EIA.

In comparing the alternatives for the TMF options (Options 1, 2, 3 and 4) the following variables were considered:

Soils	Sensitivity of Soil
	Erosion Potential of Soil
	Soil Depth Effective Rooting Depth (ERD)
	Soil Structure and Workability
Land Capability	Arable Potential
	Grazing Potential
	Wilderness Potential
	Wetland Potential
Land Use	Presence of dwellings or people on the land
	Presence of Infrastructure
	Presence of livestock or cultivation on land

Table 4.1 reflects a straight comparison (no weighting of aspects) of the four alternative tailings management facilities (TMF) that are considered. A scale of 1 to 9 was used, where 1 = Highly Suitable and 9 = Not Suitable.

The results show TMF4 (East central) considered the most preferred with TMF 1 being considered the least preferred sites purely from a soil, land use and land capability point of view. TMF 2 is considered the next most preferred area after TMF 4.

Table 4.1: Alternative Assessment Matrix

YAOURE GOLD MINE PROJECT - ALTERNATIVES ASSESSMENT ANALYSIS - TAILINGS MANAGEMENT FACILITIES										
Alternatives Analysis Matrix										
Considerations			TMF OPTIONS							
Account	Sub-account	Indicator	TMF 1		TMF 2		TMF 3		TMF 4	
			Score	Description	Score	Description	Score	Description	Score	Description
Aspects of Physical Environment	Present Land Use	Habitation & Existing Use	2	No permenant habitation noted.	3	Limited to no permaant dwellings. Shelters alongside subsistance farming areas	1	No habitation on site.	1	No evidence of habitation
		Cultivation or Grazing Usage	7	Significant area of cultivated lands - estimated that 50% to 60% of area is utilised.	4	Limited but significant areas of cultivation and bush clearing for agriculture.	4	Significant area of cleared land - evidence of rotational cultivation and some annual cropping. Area accessed by tracks and footpaths. Probably a susbsistance level of farming	3	Cultivation very limited, albeit that flatness of the terrain lends itself to utilisation for tree growth (land capability)
		Subsistence usage	6	Moderate to large portion of the area of concern is cultivated?	3	It appears that the majority of the clearings are used for subsistance farming.	4	Majority of cultivated/cleared land is of a subsistance nature.	2	Limited to no evidence of subsistance farming
	Sub-account value		15		10		9		6	
	Soils	Presence of sensitive soils	5	Wet based and wetland soils are limited to the tertiary streams and waterways. Significance is small and limited, with sites of transitional zone wet based soils of depth.	6	TMF 2 planned in a non perrenial stream/valley. Significant areas of wet based and some/limited wetland soils associated with stream bottoms and stream banks with hillside seeps present but of limited concern (few in number). Wetlands to the south southast just upslope of village. Wet based soils moderately deep on ferricrete base.	6	TMF 3 planned in a non perrenial stream. Limited but significant areas of wet based and wetland soils associated with stream bottoms and a narrow strip along stream banks with hillside seeps present but of limited concern (few in number). Wetlands to the south and east of the TMF (close to power lines). Wet based soils moderately deep on ferricrete base.	4	Sensitive soils are limited to narrow zone of wet based and some wetland soils associated with the non perrenial stream and water ways.
		Soil Workability	5	Variable soil depths from small area of very shallow ferricrete pavement (hard plinthite) in the south of the area - poor soil cover and easily eroded, to moderate and deep sandy clay loams, more friable and easily stripped and stockpiled. The we tbased materials are more sensitive, clay rich and some structured. More difficult to handle.	4	Variable soil depths from shallow on hard plinthite predominantly in the west - poor soil cover and easily eroded, to moderate and deep sandy clay loams, more friable and easily stripped and stockpiled. The wetbased materials - more sensitive, clay rich and some structure. More difficult to handle.	4	Generally moderately deep (70cm) to shallow (<50cm) sandy loams and sandy clay loams associated with the transition zone soils. Overall soils are moderately easily worked and stored, albeit that compaction and erosion are an issues to be managed.	3	Moderately deep Sandy clay loams for the most part with some relatively shallow rooting depths on hard plinthic sub strata. Materials moderately easily worked for all but the shallow wet based materials.
		Erosion Sensitivity	3	Moderate to deep and flatter gradients, moderate clay, and better than average organic matter content - Moderate to Low erosion index Risk is increased if soils are not protected, or if impacted by vegetation removal.	4	Undulating to steep slopes in valley profiles, flattening to the west. The moderate to high clay percentages for all but the deeper sandy loams (+20%) and good organic carbon stores = Low to Moderate erosion if not protected.	4	Moderately steep to undulating terrain, moderate to high clay and good carbon stores = moderately sensitive to erosion if unprotected. Management necessary once vegetation is removed.	3	Undulating to flat gradients for the most part, moderate to good clay percentages and better than average organic matter content = Moderate to low erosion, but high if disturbed of vegetative cover.
	Sub-account value		13		14		14		10	
	Land Capability	Arable Potential of Soils	7	Significant area of cultivated lands on some of the better potential arable soils. Generally moderate to deep rooting depths (80cm to +120cm) and transition zone soils (signs of wetness at depths >120cm). Soil nutrients needed for commercial activities.	3	Variable rooting depths (<20 on Hard Pan Fe, to +120cm), generally increasing to the soouth an west. Moderate to low arable land potential if cultivated and additives are considered. Majority of soils are dryland or transition zone with signs of wetness at death on lower midslopes. Grazing land potential rating considered for majority of the TMF area.	5	Generally moderate to good rooting depths (60cm to 100cm) on all but the iron rich lithologies that returned very shallow hard pan ferricrtes. Limited on this area - Moderate to low arable land potential if cultivated unless additives considered. Majority of soils are dryland or transition zone with signs of wetness at death on lower midslopes. Grazing land potential rating.	4	Soils rate as moderate arable potential for all but the shallow rooted materials and wet based soils associated with the stream environment and the areas of intermediate soil depth that rate as having a grazing potential - majority.
		Grazing Potential of Soils	5	Significant area of moderate to good grazingland potential sites, good depths for all but the south central portion (shallow Ferricrete pavements). Limited wetland status but wider and deeper occurrence of wetness features in profile.	5	Significant areas of moderate to shallow soil considered of wilderness status, while deeper soils are of a grazing land potential. The moist grasslands and wet based soils are regarded as sensitive.	5	Significant areas of grazing land potential (majority of the study area), with moist grasslands on transition zone soils associated with the lower midslope just upslope of the un-named stream and narrow wetland environments.	5	The majority of the area of concern rates as grazing land potential on deep moist grasslands and/or arable potential land capability.
		Conservation Potential of Soils	3	Limited areas of conservation status	4	Significant but smaller area of wetland soils to be disturbed (valley bottoms) with larger areas of slightly less sensitive transition zone wet based soils and moist grasslands associated with stream banks and lower slopes. Sensitivity to being worked, possible licensing in terms of wetland delineation guidelines.	6	Limited but significant wet based soils will be disturbed. Transition zone moist grasslands and some shallow rocky soils will be impacted.	3	Limited areas of conservation status. Limited to the narrow zone of wet based soils and wetland status along stream and water ways.
	Sub-account value		15		12		16		12	
	Overall Value		43		36		39		28	
				> Sub Agric,		More agric and more wetbased soils		Variable soil depths, poor arable		Flatter and less wetlands
				North east		South central		South west		Central

The table is a straight comparison of the five sites using a scale of 1 to 9, where 1 = Highly Suitable and 9 = Not Suitable.
Lowest score = Best Scenario.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT - PHILOSOPHY

The impact assessment methodology aims to identify and quantify the environmental and/or social aspects of the proposed activities inclusive of any alternatives, to assess how these aspects, actions and activities will affect the existing state, and link these aspects to variables that have been defined in terms of the baseline study.

The impact assessment has defined a maximum acceptable level of impact for each of the activities or variables, inclusive of any standards, limits and/or thresholds, and will assess the impact in terms of the significance rating as defined.

This will require that the direct, indirect and cumulative effects are considered, and that the common sources of impact are detailed.

The environmental aspects are all part of the information that is needed in decision making, with an understanding of how the soils and land capability will be affected, these aspects being just part of the overall sustainability equation that needs to be balanced.

With the information available (historic and current) and the results of the comprehensive baseline studies (soils and land capability), and with the development plan for the Yaoure Gold Mining Project, the areas of concern have been assessed and management measures proposed to minimise and mitigate the impacts wherever possible.

The principle of “No Net Loss” has been followed wherever possible. However, the development of any open cast mining project and its associated infrastructure and development will require a significantly large surface area to be disturbed for a measurable period of time.

This will inevitably result in the present land uses and land capabilities being changed. These activities will challenge the concept of “No Net Loss.”

Based on the outcomes of the impact assessment, the site specific management planning and mitigation measures have been defined and detailed. This will include defining what the mitigation will do to reduce the intensity and probability of an impact, specify a performance expectation for the mitigation proposed, and ensure that the prescriptive mitigation proposed is clear, site specific and practical.

Aas part of the practical management plan, a monitoring system has been defined and where available any legal limits or provisions are listed.

Soil sensitivity is one of the variables used when considering the impact significance through the Life of Mine as it will influence the way the soils are handled, stored and replaced. A materials workability is of consequence to the long term sustainability of the resource. Soil sensitivity or robustness* are also important to the understanding of Ecosystem Services and the roll these aspects play in the overall weighting of the various impacts that are expected to affect the biophysical and ecology of the project area (Refer to Figure 5.1 – Soil Sensitivity Plan).

Of specific relevance and importance in the Project area is also:

- The variation in soil structure, texture and clay content of the soils combined with the presence of a prominent ferricrete (evaporite) layer at the base of many of the soil profile ("C" Horizon), all make for a complex of natural conditions that are going to be extremely difficult to replicate during the rehabilitation stage and at closure;
- The potential and probable loss of soil water and the "perched" aquifer that is believed to occur as a result of the ferricrete inhibiting/barrier layer will need to be assessed and understood as a function of the ecological balance;
- The moderately good concentrations of organic carbon but relatively low nutrient stores noted for many of the soils will also require that a sound soil utilisation plan and management system is adopted based on the best impact assessment information; and
- The concept of "utilisable soil" storage will be tabled as a basic management tool, and a function of good environment practise.

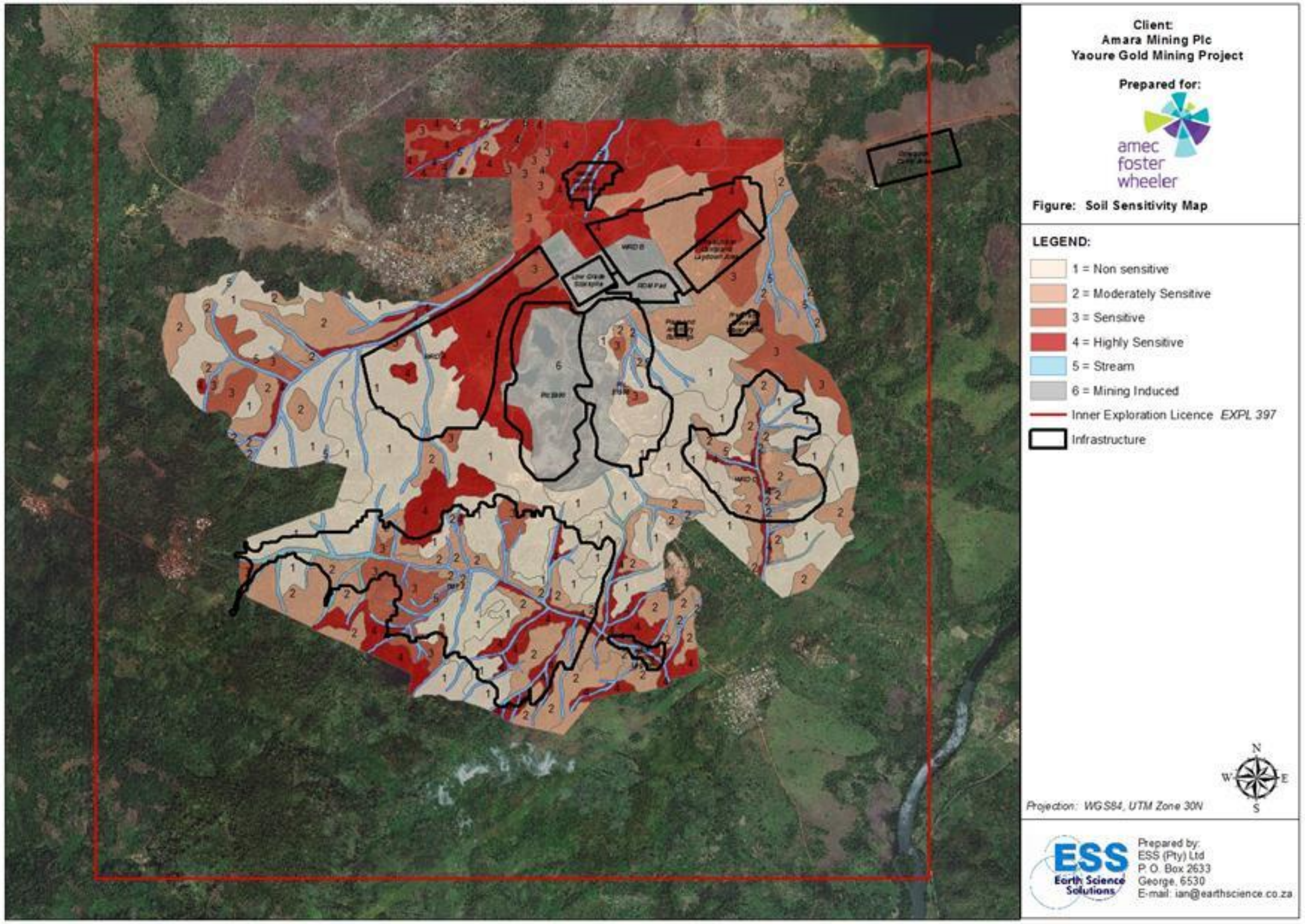
These factors will be important in the environmental assessment and final management plan that is tabled, with the "separation" and management of the differing materials at the removal/soil stripping stage (construction) forming the basis for economically and sustainable rehabilitation at closure.

The moderately complex nature of the geology (structurally deformed and folded lithologies, with a moderately steep inclination) and geomorphology of the area, its sub-tropical to tropical climate, all play a significant role in the soil forming process, and have a bearing on the sensitivity and/or vulnerability of the materials when being worked or disturbed.

These factors are important in planning the construction and operational activities, and will determine the success of the rehabilitation planning for the future.

** The sensitivity or robustness of a soil in the context of a development plan is simply defined as: "**an estimate of the soils ability to maintain its original strengths and characteristics when it is worked or impacted"**. This is contextualised in terms of the eco system services and legal requirements that might also pertain to a particular region)*

Figure 5.1: Soil Sensitivity Map



6.0 ENVIRONMENTAL IMPACT ASSESSMENT

The development planning has been considered and details of activities and infrastructure planned for the construction phase the operational phase and the closure phases have been noted as part of the environmental impact assessment.

An assessment of the environmental impacts that these activities could incur has been carried out and measured against the existing environmental state using the Impact Significance Rating method sullied to us by the lead consultants. The outcomes are tabled as stand-a-lone ratings, and should be considered as un-weighted values based on the soils, land capability and land use alone.

This section assesses and quantifies the environmental aspects of the activities in terms of how they will affect the existing environmental state and details where possible/available the maximum acceptable level of impact for each of the variables/activities listed.

Based on these findings, the significance of the impact is rated in terms of its unmanaged and managed state, with the management recommendations forming the basis of the Environmental Management Plan.

The occurrence of evaporites and ferricrete is indicative of wetness (present or historical) within a profile, and although many of the ferruginous soils mapped are believed to be associated with relic land forms (historical wetness), there are a number of areas where these features are considered to be a function of their topographic position (low lying areas) and the wetness within the profile.

These features, both the historic relic land forms as well as the recent shallow wet based soils are considered sensitive to highly sensitive features, and are important to the biodiversity and ecology of an area and need to be understood in the context of the overall systems that sustain the pre development environment.

In terms of wetland delineation these highly sensitive areas need to be considered carefully if they are within the area of proposed impact.

The noted (baseline study) differences in the texture of the different soils, the soil depth variations, composition of the “C” horizon (ferricrete), wetness of subsoil’s and the structure of the different soil groups is of importance in assessing the potential impacts and the relative sensitivity that is assigned to the soil groups and land capabilities.

The difference in the significance of the expected impacts based on soil form or group alone can be used in the alternatives assessment for the infrastructural design criteria and placement.

The assessment is confined to the project footprint as delineated and its immediate surroundings, and as such the “spatial extent is regarded as “Site Only” or “Localised” depending on how far the effects of erosion (wind and water) are predicted to extend (sedimentation of streams and rivers and dust impacts off site downwind of the TMF, WRD and mining activities).

The infrastructure planned for the facility will include (Figure 6.1) large and heavy structures and deep excavations (open cast mining, water dams, large milling and screening equipment etc.). These will entail the removal of significant quantities of soil, and often the complete removal of soil and soft overburden in places were the foundations for the larger structures are to be excavated and where the open cast mining is planned.

The haulage ways (open pit to loading/RoM Stockpile) and conveyencing routes will be required to carry heavy vehicles and loads from the open pit to the Run of Mine (RoM) stockpiles/conveyer loading area, and will require strong foundations with resultant deep excavation and engineering of the sub base, while the access roads and general service ways will require less intensive engineering and will not be as invasive on the natural materials.

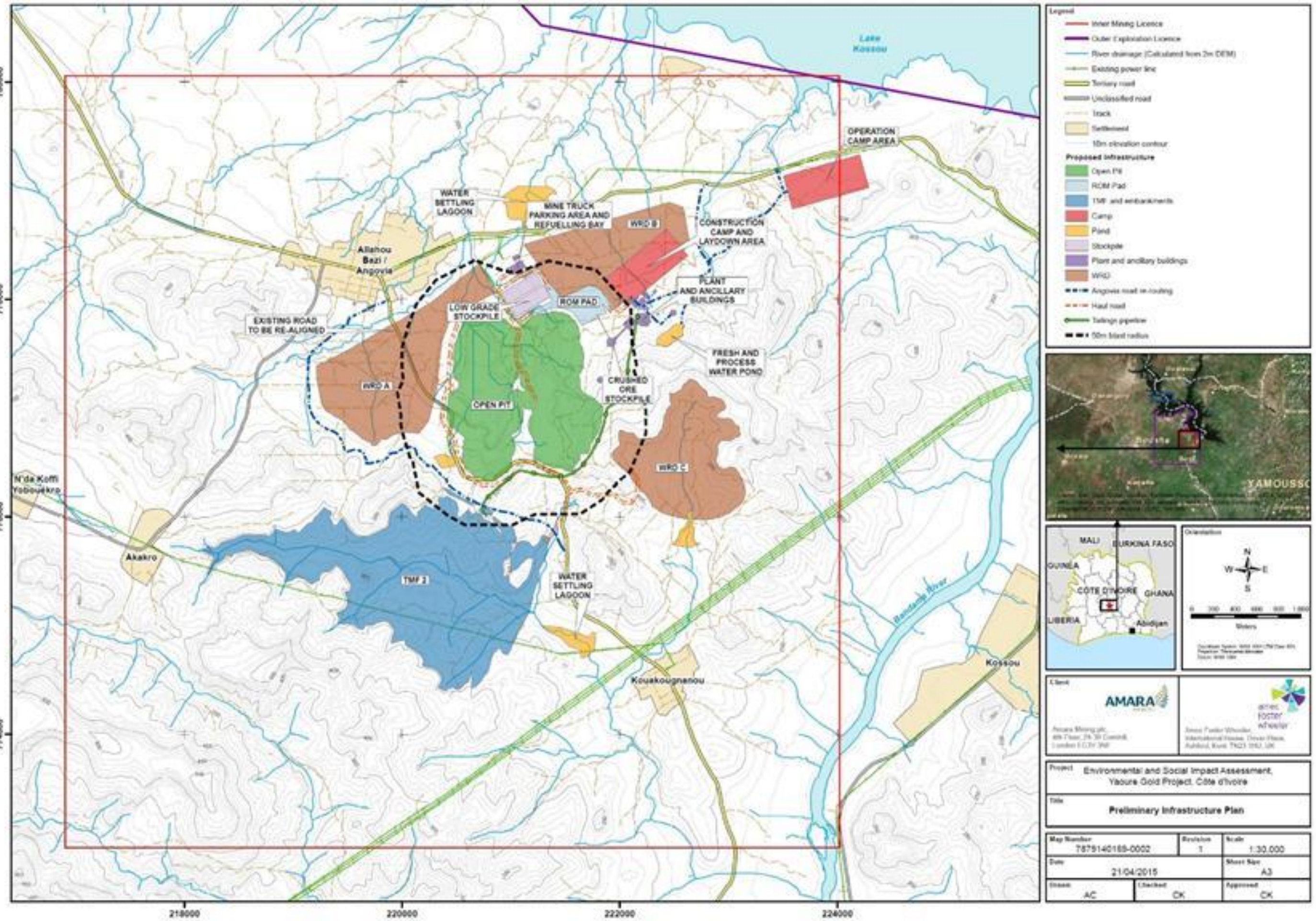
These soils will be sterilised and lost from the system for the life of the operation and beyond (permanent TMF and WRD).

A number of site specific baseline (existing environment) conditions are reiterated here as they are of relevance if the impact significance of the activities being planned are to be understood.

Of importance are:

- The soil physical and chemical composition (structure and texture) and the associated **workability** of the materials;
- The utilisable **depth** of soil to be saved/stripped and stored;
- The underlying **ferricrete layer** and its function as a barrier to soil water movement down the profile. This will in almost all cases [deep foundations or facilities (dams etc.)] be destroyed and possibly removed from the system;
- All/any wet based soils/**wetlands** are considered to be ecologically sensitive and important; and
- The significant area of **wet based soil** that is being considered as part of the footprint to the developments (TMF and some WRD).

Figure 6.1: Mine Plan



These aspects (soil and land capability) will have a bearing on the significance ratings being assigned to the overall impact statement, the effects of the actions and activities having a definite localised negative impact that is of significance to the general environmental aspects and ecosystem services, as well as the ecological functionality of the area.

These variables will also have a bearing on the management recommendations made.

In any assessment of impact it is important to understand the activities that are being planned. It is these actions that will need to be measured against the environments natural ability to attenuate and manage the impacts, while assigning meaningful management measures to those that cannot be naturally managed.

Planned Activities (Refer to Figure 6.1 – Mine Plan 2015)

The key activities planned for the development include:

- Open pit mining
- ROM pad
- Waste Rock Dumps
- TMF
- Access roads
- Internal, haulage and service roads
- Processing plant
- Potable and process water supply
- Additional power supply and distribution
- Process-and storm water management facilities
- Permanent accommodation facilities
- Temporary facilities, including contractors' camp, mine staff village and sewage treatment facility
- Offices, workshop, and laydown areas
- Fuel storage facilities
- Explosives, cyanide and reagent/consumable storage areas
- Waste water and sewage treatment facility
- Communication system
- Waste management facility.

With an understanding of the general high level working plan of the proposed project and the support facilities and infrastructure that will be used to convey and process/beneficiate the raw materials, the disposal of the waste product (tailings and rock) and the delivery of the final product from the site, the following concerns and probable impacts that could affect the soils and associated land capability are considered to be of a medium to high significance rating if they are not well managed.

The impacts that the proposed development will have on the soil, land use and land capability will include:

- The loss of the soil resource due the change in land use and the removal of the resource from the existing system (sterilisation). These effects are generally associated with the construction of the infrastructure and support facilities and the use of the footprint area for open cast mining activities. These activities will definitely result in the complete loss of the soil resource for the life of the project and possibly for some time after closure. The effects are however reversible for the majority of the activities and actions that are being planned. However, the open cast mining, the footprint to the TMF and the WRD are the exceptions to this and are all features that will be left permanently in place;
- The management of waste rock and the tailings will sterilise the soils permanently (if soils are not removed), and if not well managed;
- The loss of the soil resource due to erosion (wind and water) of unprotected materials (removal of vegetative cover and/or topsoil);
- The loss of the utilisation potential of the soil and land capability due to compaction of the footprint areas and areas adjacent to the constructed facilities;
- The permeant loss of the land use for areas to be mined by open cast mining, and the footprint of the WRD and the TMF;
- The contamination of the resource due to spillage of raw materials or final product and the possibility of spillage of reagents transported, stored and used on site and in the process;
- The contamination of stored or in-situ materials due to impacts of dust or dirty water from the project area, d haulage ways and transport routes; and
- The loss of the soil utilization potential due to the disturbance of the soils and potential loss of nutrient stores through infiltration and de-nitrification of the materials while in storage or due to disturbance of the materials.

6.1 Impact Assessment

6.1.1 Pre-Construction and Construction Phase

Issue - Loss of utilisable resource (sterilisation and erosion), compaction and contamination or salinisation.

The construction phase will include a number of different activities. These include:

- The stripping of all utilisable soil (Top 450mm to 750mm depending on activity);
- The preparation (levelling and compaction) of lay-down areas, foundations and pad footprint areas for stockpiling of utilisable soil removed from the footprint to the open cast areas all infrastructural footprints, the Run of Mine stockpile, access roads and haulage ways;
- The storm water management system (Dams, Water Reservoir etc.), and the foundations for the Beneficiation/Recovery Complex and its associated support infrastructure (workshops, diesel bays, stores etc.);

- The clearing, stripping and stockpiling of soil as a result of the construction of all water supply and electrical power supply servitudes and reticulation systems;
- The use of heavy machinery over unprotected soils;
- The creation of dust and loss of materials to wind and water erosion due to the removal of vegetative cover and the exposure of the soils; and
- The possible contamination of the soils by dirty water, chemicals and hydrocarbons spills (dust and dirty water runoff).

Impact Significance

The loss of the utilisation of the soil resource will impact the ecosystem services (food, building materials and medicinal plants) and present land use practice (artisanal mining, along with varying intensity of subsistence and semi commercial cultivation). These activities are perceived to be of great economic benefit to the local economy and land owners and contribute in no small way to the ecosystem services of the area and surrounds.

Indirect impacts on the availability of the soil and land as a resource will be evident with the mining and its associated activities limiting the utilisation potential of specific sites, some permanently.

The construction activities required for the mining and its support activities will, if un-managed and without mitigation:

- Have a definite high negative impact on the environment due to the loss of the soil materials and associated ecosystem services and thus the use of the utilisable resource;
- Have the potential for contamination (hydrocarbon and reagent chemical spills, raw materials and spillage of recovery associated reagents such as cyanide), compaction of working/laydown areas and storage facility footprints and the potential for erosion (wind and water – dust and suspended solids) over unprotected areas;
- Will potentially continue throughout the construction phase and into the operational phase;
- Will be permanent but reversible (can be broken down and rehabilitated), for the most part, albeit that the Open Pit, TMF and WRD will be permanent features, while; and
- The impacts will for the most part be confined to the site only (localised), while uncontrolled runoff and exposure could see excessive sedimentary load in the streams and rivers and dust contamination off-site.

However, with management, the loss, degree of contamination, compaction and erosion of the resource can be mitigated and reduced to a level that is more acceptable.

The reduction in the significance of the impact can be achieved by:

- Limiting the area of impact to as small a footprint as possible, inclusive of waste management facilities, resource stockpiles, the length of servitudes, access and haulage ways and conveyencing systems wherever possible;
- Construction of the facility and associated infrastructure over the less sensitive soil groups (reduce impact over wetlands and soils sensitive to erosion and/or compaction);
- Instilling an awareness during the life of mine that the resource will need to be stored and managed;
- The development and inclusion of soil management as part of the general environmental management activities and the independent auditing of this management;
- Concurrent rehabilitation of all affected sites that are not required for the operational phase e.g. rehabilitation of temporary structures and footprint areas used during the feasibility investigation (geotechnical pits, trenching etc.) and the construction phase;
- Effective soil stripping during the dryer months when the soils are less susceptible to erosion;
- Separation of the utilisable soils and ferricrete base materials from each other and from the soft overburden where possible;
- Effective cladding of the berms and soil, stockpiles/heaps with vegetation or large rock fragments, and the minimising of the height of storage facilities to 5m and soil berms to 1,5m wherever possible;
- Restriction of vehicle movement over unprotected or sensitive areas, this will reduce compaction; and
- Soil amelioration (cultivation) to enhance the oxygenation and growing capability (germination) of natural regeneration and/or seed within the stockpiled soils (maintain the soils viability during storage) and areas of concurrent rehabilitation.

It is evident from audits undertaken in the gold mining industry, that failure to manage the impacts on this important resource (soil) will result in both financial as well as ecosystem services loss, with a resultant much higher significance rating and downstream effects on the ability to get closure for the site.

Residual Impact

The above management procedures will likely reduce the significance of the impacts to moderate in the medium term (Refer to Table 6.1– Significant Ratings Construction Phase).

Table 6.1: Pre Construction and Construction Phase Impact Significance

Significance Rating - Yaoure Gold Mining Project									
PRECONSTRUCTION PHASE									
Activity/Impact	Site Clearing and Grubbing of the Footprint areas associated with the open cast mining and development of waste storage and management (WRD and TMF), conveyencing and haulage ways and development of beneficiation plant and support infrastructure footprint.								
Project Phase	Preconstruction Phase								
Impact Summary	Loss of soil resource due to soil stripping where mining and associated infrastructure is to be constructed, potential for contamination and perminant loss to erosion and compaction								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	6	**90**	-ve	High
Management Measures	Limit the size of area of impact to a minimum.								
	Site selection for infrastructure on less sensitive soils, restriction on No Go and highly sensitive materials								
	Stripping of soils during less windy and drier months and concurrent rehabilitation of areas that are nolonger needed for the project (trenches, exploration pads etc., and/or utilisation of erosion control mechanisums.								
After management Measures	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	3	2	3	6	**72**	-ve	Medium
Activity	Establishment of Contarctors Laydown area and camp, staff village and associated access roads etc.,								
Project Phase	Preconstruction Phase								
Impact Summary	Loss of soil resource due to soil stripping of soil from the related footprint/s.								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	6	**90**	-ve	High
Management Measures	Limit the area of impact to a minimum								
	Site selection for infrastructure on less sensitive soils, restriction on No Go and highly sensitive materials								
	Stripping of soils during less windy and drier months if possible to limit erosion, and/or utilisation of erosion controls.								
After management Measures	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	3	2	3	6	**72**	-ve	Medium

CONSTRUCTION PHASE									
Activity	Development of Ramp and opening of open cast sections, construction of beneficiation plant and associated support infrastructure (Offices, workshops etc.) and the construction of conveyencing systems and routes. Also undertake construction of stormwater controls (dams and trenches/berms) and activily stockpile and manage the soils removed from the footprint to all infrastructure (including WRD and TMF).								
Project Phase	Construction Phase								
Impact Summary	Loss of resource and eco system services (soil resource), erosion, compaction, sterilisation and contamination of in-situ and stored resouce (stockpiles)								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	6	**90**	-ve	High
Management Measures	Restriction of activities to as small an area as possible, and restriction to less sensitive soil forms								
	Use of erosion control systems as part of design criteria, concurrent rehabilitation and awarness of climatic conditions during construction (limiting of earthworks during very wet or very windy conditions)								
	Inclusion of soil utilisation and management as part of management operations and auditable activities (general housekeeping)								
	Management of vehicle movement over unprotected soils								
After management Measures	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	4	2	4	6	**84**	-ve	Medium
Activity	Construction of Contractors Camp and Staff Village, service road and electrical/water reticulation								
Project Phase	Construction Phase								
Impact Summary	Loss of resource and eco system services (soil resource), erosion, compaction, sterilisation and contamination of in-situ and stored resouce (stockpiles)								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	6	**90**	-ve	High
Management Measures	Restriction of activities to as small an area as possible, and restriction to less sensitive soil forms								
	Use of erosion control systems as part of design criteria (vegetative cover - vetiver intervention), concurrent rehabilitation and awarness of climatic conditions during construction (limiting of earthworks during very wet or very windy conditions)								
	Inclusion of soil utilisation and management as part of engineering designs, management operations and auditable activities (general housekeeping)								
After management Measures	Management of vehicle movement over unprotected soils								
	Management	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	3	2	3	6	**72**	-ve	Medium

6.1.2 Operational Phase

<u>Issue - Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinisation.</u>

The operation of the mining venture (open cast mining and associated activities) will see the impact of transportation of materials into and out of the complex, the potential for spillage and contamination of the in-situ and stockpiled materials, contamination due to dirty water run-off and/or contaminated dust deposition/dispersion, the de-nutrification of the stockpiled soils due to excessive through flow of rain water on unconsolidated and poorly protected soils and the flushing of the nutrient pool from the stockpiled materials if not well protected.

The potential for compaction of the in-situ materials by uncontrolled vehicle movement and the loss to the environment (down-wind and downstream) of soil by wind and water erosion over un-protected ground are also possible if not well managed.

In summary, the operation will, if not well managed result in:

- The sterilisation of the soil resource on which the facilities are constructed. This will be an on-going for the duration of the operation;
- The creation of dust and the possible loss (erosion) of utilisable soil down-wind and/or downstream and the potential for contamination of the soils and water bodies from dust fallout, a further loss of a valuable resource and potential impact on downstream/downwind users leading to cumulative impacts in terms of air and water quality; These will include the present farming impacts and artisanal mining, both of which have had significant effects on the natural environment already. The effects of erosion and sediment loads to the streams and rivers are particularly significant;
- The compaction of the in-situ and stored soils and the potential loss of utilisable materials from the system;
- The contamination of the soils by dirty water run-off and or spillage of hydrocarbons by vehicles, and reagents (cyanide and nitrates) from the processing facility and blasting respectively, and the potential for dust and emissions from the recovery process;
- Contamination of soils by use of dirty water for road wetting (dust suppression) and irrigation of the stockpile vegetation;
- Potential contamination of soils by chemical spills of reagents being transported to site;
- Sterilisation and loss of eco system services in the form of the soil nutrient pool, organic carbon stores and fertility of stored soils; and
- An impact on soil structure and the soil water balance.

Un-managed soil stockpiles and soil that is left uncovered/unprotected will be lost to wind and water erosion, will loss the all-important and nutrient content and organic carbon stores (fertility) and will be prone to compaction.

Of a positive impact, will be the rehabilitation of any temporary infrastructure used during the start-up and construction phase.

Impact Significance

The result of the operation on the soil resource will have a medium to high negative significance rating in the un-managed state, that will last for the life of the operation (permanent to irreversible if not rehabilitated) and be confined to the immediate site.

It is inevitable that some of the soils will be lost during the operational phase if they are not well managed and a mitigation plan is not made part of the general management schedule.

The impacts on the soils during the operational phase (stockpiled, peripheral soils and downstream (wind and water) materials) may be mitigated with well initiated management procedures.

These should include:

- Minimisation of the area that can potentially be impacted (eroded, compacted, sterilised or de-nutrified) and restriction of activities to the actual footprint areas;
- Timeous replacement of the soils to minimise/reduce the area of affect and disturbance (concurrent rehabilitation wherever possible);
- Effective soil cover and adequate protection from wind (dust) and dirty water contamination – vegetate and/or rock cladding;
- Regular servicing of all vehicles in well-constructed and bunded areas;
- Regular cleaning and maintenance of all haulage ways, conveyencing routes and service ways, drains and storm water control facilities;
- Containment and management of spillage;
- Soil replacement and the preparation of a seed bed to facilitate and accelerate the re-vegetation program and to limit potential erosion on all areas that become available for rehabilitation (temporary servitudes); and
- Soil amelioration (rehabilitated and stockpiled) to enhance the growth capability of the soils and sustain the soils ability to retain oxygen and nutrients, thus sustaining vegetative material during the storage stage.

It will be necessary as part of the development plan to maintain the integrity of the stored soils so that they are available for rehabilitation at decommissioning and closure.

If the soil quantities and qualities are (utilisable soils) managed well throughout the operational phase, rehabilitation costs will be reduced and natural attenuation will more easily and readily take effect. This will result in a more sustainable "End Land Use" being achieved.

Residual Impact

In the long term (Life of the operation) and if implemented correctly, the above mitigation measures will reduce the impact on the utilisable soil reserves (erosion, contamination, sterilization) to a significance rating of moderate or possibly low (Refer to Table 6.2).

However, if the soils are not retained/stored and managed, and a workable management plan is not implemented the residual impact will definitely incur additional costs and result in the impacting of secondary areas (in order to obtain cover materials etc).

Table 6.2: Operational Phase - Impact Significance

OPERATIONAL PHASE									
Activity	Open Cast Mining and transport of raw materials/ore to beneficiation plant.								
Project Phase	Operational Phase								
Impact Summary	Loss of soil resource and eco system services (erosion), sterilisation of stockpiled materials (loss of soil nutrients) , contamination and salinisation of in-situ and stored materials and associated streams by dirty water and possible hydrocarbon spills and wind blown dust, and the compaction of materials exposed to unprotected utilisation.								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	7	**105**	-ve	High
Management Measures	Minimisation of area of footprint								
	Concurent and timeous replacement of the soils after mining and as part of concurrent rehabilitation								
	Effective soil and vegetative cover to in-situ and stored materials, restriction on heights of soil dumps, and								
	Control and auditing of vehicle movements and regular servicing of equipment								
	Storm water and dirty water management of all facilities - runoff and ponding								
After management Measures	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	3	2	4	6	**78**	-ve	Medium
Activity	Conveyencing/Transport of Raw Materials/Ore to processing plant, Beneficiation, waste management and concurrent rehabilitation, Management of RoM Stockpiles and Management of Stored Resource (soils and utilisable resources).								
Project Phase	Operational Phase								
Impact Summary	Loss of resource and eco system services, sterilisation of soils and loss of soil utilisation potential, salinisation and/or contamination due to spillage of raw materials, dust and/or dirty water or hydrocarbons from vehicles and machinery. Compaction of peripheral soils if unprotected.								
Potential Impact Rating	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Unmanaged	4	4	3	4	6	**90**	-ve	High
Management Measures	Minimisation of footprint of potential impact and concurrent rehabilitation of areas that are nolonger needed for the activity								
	Effective soil and vegatitive cover and timeous replacement of soils onto areas that can be rehabilitated								
	Regular cleaning and maintenance of systems and containment of spillage. Adequate stormwater controls.								
	Maintenance of integrety of stored soils, monitoring of nutrient store etc.								
After management Measures	**Management**	**Likelyhood Probability**	**Duration**	**Extent Spatial**	**Magnitude Scale**	**Sensitivity**	**Significance**	**Pos/Neg**	**Conf. Level**
	Managed	4	3	2	4	6	**78**	-ve	Medium

6.1.3 Decommissioning & Closure Phase

Issue: Net loss of soil volumes and utilisation potential due to change in material status (Physical and Chemical) and loss of nutrient base.

The impacts on the soil resource during the decommissioning and closure phase have both a positive and a negative effect, with:

- The loss of the soils original nutrient store and organic carbon by leaching of the soils while in storage;
- Erosion and de-oxygenation of materials while stockpiled;
- Compaction and dust contamination due to vehicle movement while rehabilitating the area;
- Erosion due to slope stabilization and re-vegetation of disturbed areas;
- Contamination of replaced soils by use of dirty water for plant watering and dust suppression on roadways; and

- Hydrocarbon or chemical spillage from contractor and supply vehicles.

Positive impacts include:

- A reduction in areas of disturbance and return of soil utilization potential;
- The uncovering of areas of stored materials; and
- The rehabilitation of compacted materials.

Impact Significance

The impact will remain the net loss of the soil resource if no intervention or mitigating strategy is implemented.

The significance rating will remain medium to high and negative for all of the activities if there is no active management (rehabilitation and intervention) in the decommissioning phase, and closure will not be possible.

This will result in an irreversible impact that is continuous.

However, with interventions and well planned management, there will be a reduction in the rating of significance to a medium to low as the soils are replaced and fertilization of the soils is implemented after removal of the infrastructure. Once completed, the significance rating will be positive, with a moderate significance.

Ongoing rehabilitation during the operational and decommissioning phases will bring about a net long-term positive impact on the soils, albeit that the land capability will retained at a grazing land status.

The significance rating of the rehabilitation activities during decommissioning and closure will be medium and negative due to the necessity for vehicle movement while removing the demolished infrastructure and rehabilitating the operational footprint(s).

Dust will potentially be generated and soil will probably be contaminated, compacted and eroded unless good management measures are implemented.

The positive impacts of rehabilitation on the area are the reduction in the footprint of disturbance, the amelioration of the affected soils and oxygenation of the growing medium, the stabilizing of slopes and the revegetation of disturbed areas (Cover to WRD and parts of the TMF).

Residual Impacts

On closure of the mining operation the long-term negative impact on the soils will be reduced from a significance ranking of medium to low if the management measures set out in the Environmental Management Plan is effectively implemented (Refer to Table 6.3).

Re-creation of the ferricrete layer effect (inhibiting layer) will require both environmental as well as engineering inputs. This conclusion supposes that the utilisable soils will be available (had been stripped and stored), and the ferricrete layer (where present) had been removed and stored separately from the sandy loams and sandy clay loams.

Chemical amelioration of the soils will have a low but positive impact on the nutrient status (only) of the soils in the medium term.

Table 6.3: Decommissioning and Closure Phase - Impact Significance

<table>
<tr><th colspan="10">CLOSURE/REHABILITATION PHASE</th></tr>
<tr><td>Activity</td><td colspan="9">Rehabilitation of all infrastructural areas (Offices, Workshops, Beneficiation Plant, Haulage Ways and Non essential Access Routes, Contractors Village and Staff Village) and WRD with partial cover and rehabilitation of TMF.</td></tr>
<tr><td>Project Phase</td><td colspan="9">Closure/Rehabilitation</td></tr>
<tr><td>Impact Summary</td><td colspan="9">Net Loss of soil volume and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base (de-nutrification), potential for compaction, erosion and contamination, while reinstatement will increase the footprint of rehabilitated grazing land potential.</td></tr>
<tr><td rowspan="2">Potential Impact Rating</td><td>Management</td><td>Likelyhood Probability</td><td>Duration</td><td>Extent Spatial</td><td>Magnitude Scale</td><td>Sensitivity</td><td>Significance</td><td>Pos/Neg</td><td>Conf. Level</td></tr>
<tr><td>Unmanaged</td><td>4</td><td>4</td><td>3</td><td>2</td><td>5</td><td>65</td><td>+ve/-ve</td><td>High</td></tr>
<tr><td rowspan="3">Management Measures</td><td colspan="9">Re-instaement of the stored soils onto areas of disturbance where infrastructure has been demolished and removed.</td></tr>
<tr><td colspan="9">Contour and stabilise slopes to be free draining</td></tr>
<tr><td colspan="9">Cultivate, amelioration and oxygenation of growing medium, the planting of required vegetative cover and irrigation if required, will reduce/mange erosion, decrease compaction and stabilise the land form. This will once cover has been obtained, effectivily see the sites returned to a grazing land capability rating.</td></tr>
<tr><td rowspan="2">After management Measures</td><td>Management</td><td>Likelyhood Probability</td><td>Duration</td><td>Extent Spatial</td><td>Magnitude Scale</td><td>Sensitivity</td><td>Significance</td><td>Pos/Neg</td><td>Conf. Level</td></tr>
<tr><td>Managed</td><td>4</td><td>3</td><td>2</td><td>2</td><td>5</td><td>55</td><td>+ve/-ve</td><td>Medium</td></tr>
</table>

At closure the residual impact should, if all rehabilitation and management efforts have been complied with, result in a net positive impact, with the area being returned to a land capability of low intensity grazing or wilderness status, and the use of the land being returned to that of natural woodlands and wildlife management.

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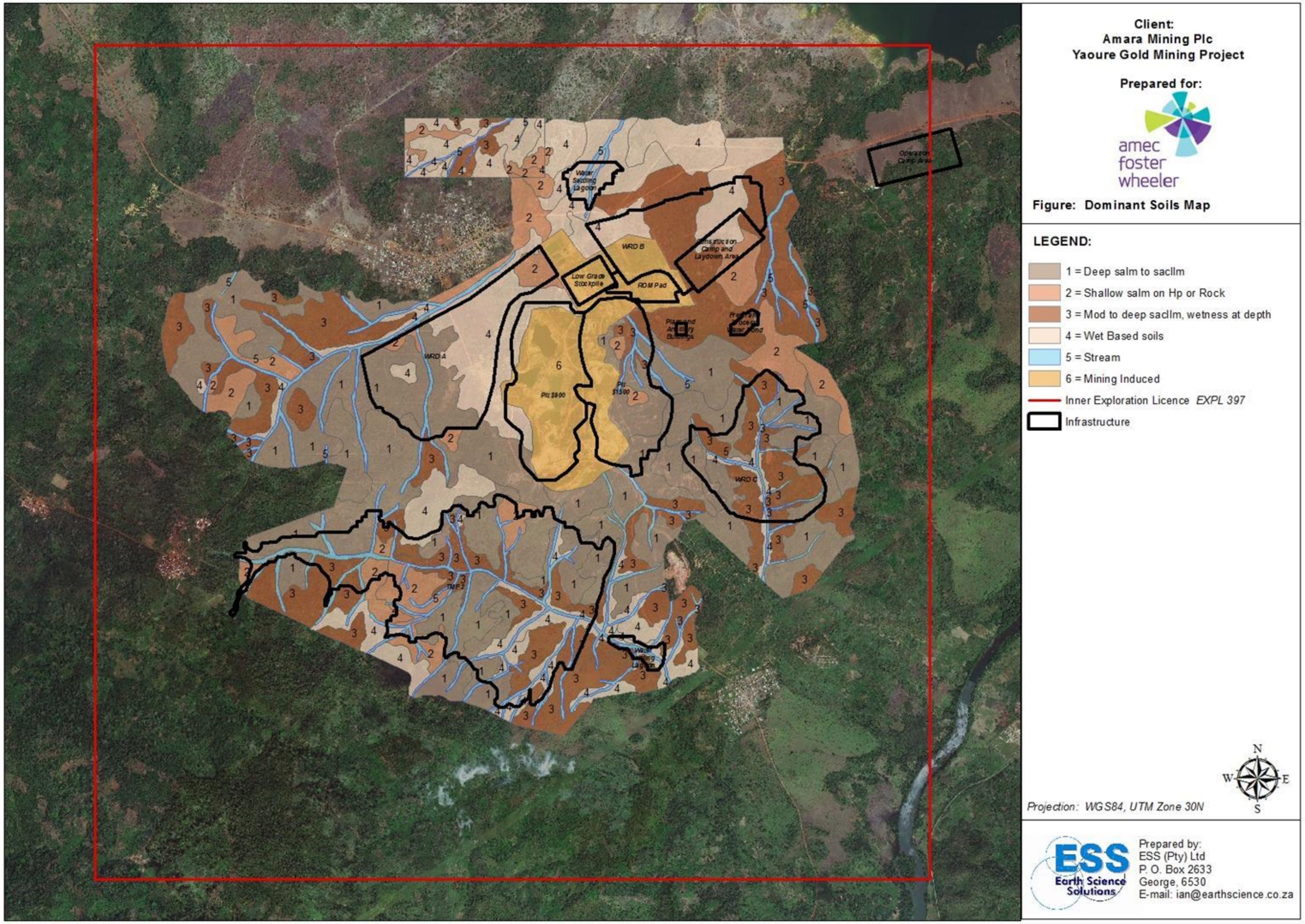
Appendix 1 - Ferricrete Classification

Appendix 2 – Detailed Maps


Client:
Amara Mining Plc
Yaoure Gold Mining Project
Prepared for:
amec foster wheeler
Figure: Dominant Soils Map
LEGEND:
1 = Deep salm to saclm
2 = Shallow salm on Hp or Rock
3 = Mod to deep saclm, wetness at depth
4 = Wet Based soils
5 = Stream
6 = Mining Induced
Inner Exploration Licence EXPL 397
Infrastructure
Projection: WGS84, UTM Zone 30N
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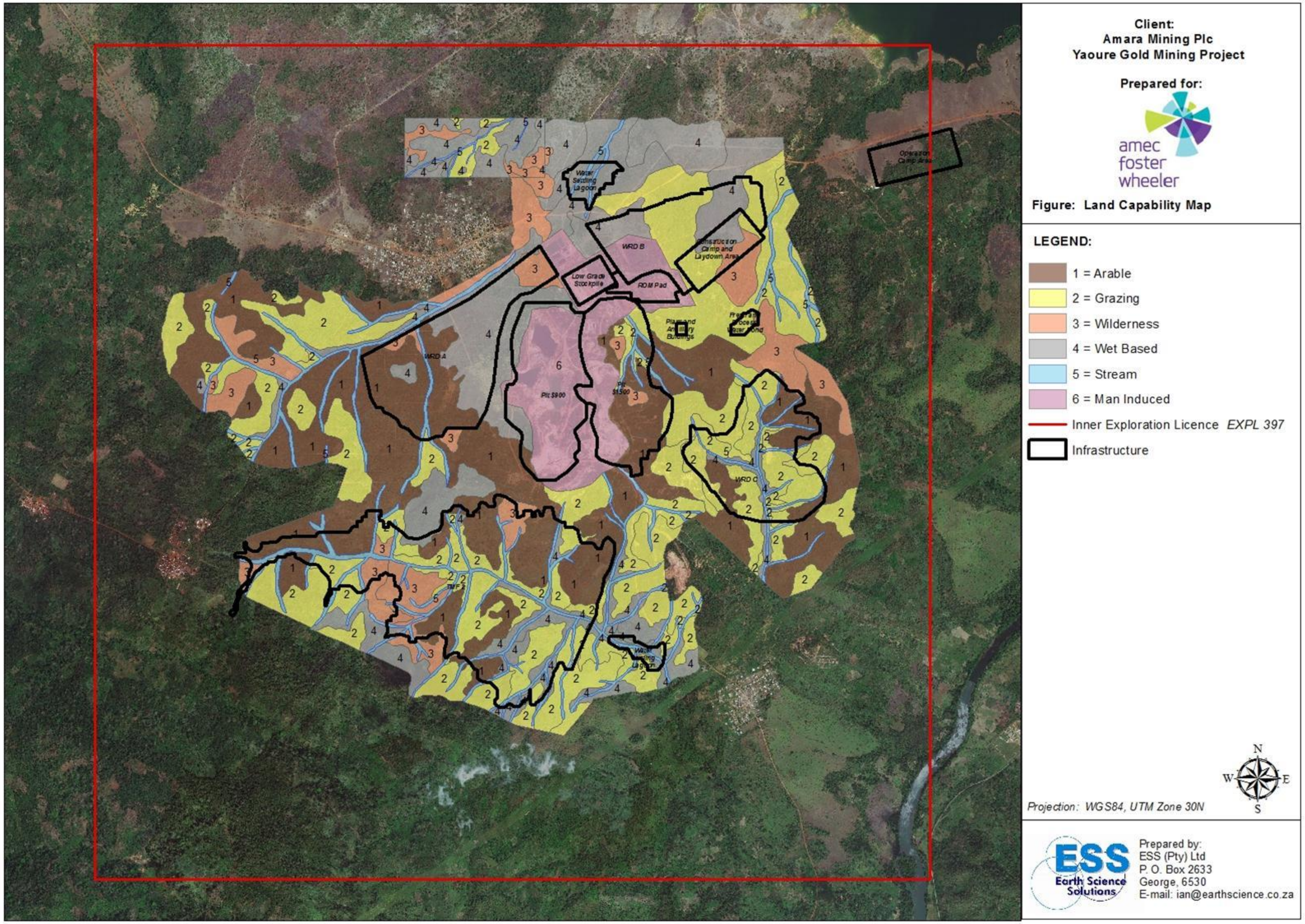
W
E
S
Prepared by:
ESS (Pty) Ltd
P. O. Box 2633
George, 6530
E-mail: ian@earthscience.co.za
WRD B
Low Grade Stockpile
ROM Pad
WRD A


Client:
Amara Mining Plc
Yaoure Gold Mining Project
Prepared for:
amec foster wheeler
Figure: Land Capability Map
LEGEND:
1 = Arable
2 = Grazing
3 = Wilderness
4 = Wet Based
5 = Stream
6 = Man Induced
Inner Exploration Licence EXPL 397
Infrastructure
Projection: WGS84, UTM Zone 30N
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W
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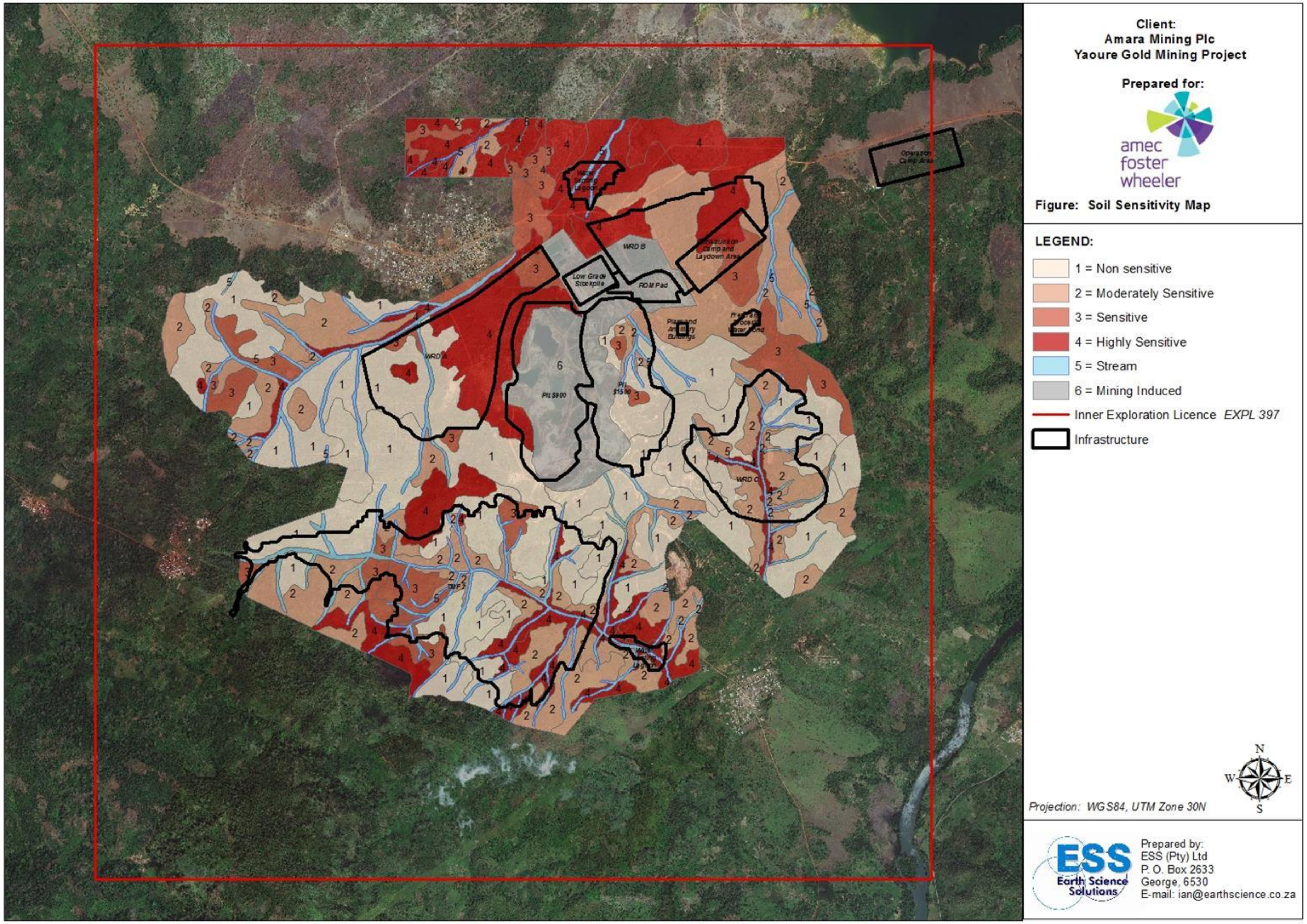
Prepared by:
ESS (Pty) Ltd
P. O. Box 2633
George, 6530
E-mail: ian@earthscience.co.za
ESS Earth Science Solutions
WRD A
WRD B
WRD C
Low Grade Stockpile
ROM Pad


Client:
Amara Mining Plc
Yaoure Gold Mining Project
Prepared for:
amec foster wheeler
Figure: Soil Sensitivity Map
LEGEND:
1 = Non sensitive
2 = Moderately Sensitive
3 = Sensitive
4 = Highly Sensitive
5 = Stream
6 = Mining Induced
Inner Exploration Licence EXPL 397
Infrastructure
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ESS
Earth Science Solutions
WRD B
Low Grade Stockpile
ROM Pad
WRD C