APPENDIX P

Soil, Land Use and Land Capability Assessment

REPORT

Turfvlakte Soil, Land Use and Land Capability Baseline and Impact Assessment Report

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1.0 INTRODUCTION

Exxaro Resources Limited (Exxaro) operates the Grootegeluk Coal Mine near Lephalale in the Limpopo Province. The farm Turfvlakte 463 LQ lies within and to the south-east of the Grootegeluk Mining Right Area. Exxaro intends to develop the farm Turfvlakte for coal mining. The Turfvlakte Project is situated approximately 30 km north-west of Lephalale, located in the Waterberg region (which forms part of the Bushveld region) of the Limpopo Province of South Africa.

Directly south of the project area is the Grootegeluk Coal Mine property border that separates Exxaro-owned land from Eskom-owned land. A provincial road close to this boundary traverses the Eskom property in an east-west direction.

As part of the Environmental Impact Assessment (EIA) process, a specialist Soil, Land Capability and Land use assessment is required. This specialist report details the findings of the desktop review, the methodology and approach used for the specialist study, the findings of the field survey and resource assessment. This report thus provides an understanding of the baseline soil conditions, prior to the intended mining activities.

2.0 PROJECT DESCRIPTION

The site layout of the project is presented in Figure 1 below. It indicates the position of the pits, haul roads, topsoil stockpile and laydown area.

2.1 Mining operations

Exxaro is proposing to expand their existing mining operations by extending the opencast mining operation to the farm Turfvlakte 463 LQ (Figure 1). The farm is located within the existing Grootegeluk Coal Mine's Mining Right, LP 46 MRC. The opencast operations will consist of two pits, namely Pit 1 and Pit 2. Pit 1 will be 158 ha in size and will be 88 m deep, while Pit 2 will be 64 ha and 109 m deep.

Sufficient coal reserves have been proven to support opencast mining. Due to faulting in the area, Benches 9A and B and Bench 11 protrude quite shallow and therefore high-quality coal can be mined at a favourable stripping ratio (Aurecon , 2018).

Grootegeluk Mine is considering two options for mining Pit 1 and Pit 2. The preferred option is to mine Pit 1 and then Pit 2 to produce 1.5 million tones per annum run of mine (ROM) coal over a period of twelve (12) years.

The alternative option is to first mine Pit 2 and then Pit 1 to produce 3 million tonnes per annum run of mine (ROM) coal over a period of seven (7) years.

The interburden and coal mined from Pit 1 and Pit 2 will be transported to and handled at the existing Grootegeluk Coal Mine plants.

The mining operations will be undertaken 24 hrs, six days a week.

2.2 Other operations

The proposed infrastructure to be established at surface in support of the coal mining operation includes haul roads connecting the proposed pits to the existing Grootegeluk Coal Mine operations, laydown area for the mine equipment and offices, water management infrastructure (sumps and pipelines), waste management area (waste skips), sub-station.

2.2.1 Materials and Waste Management

The following types of mining related materials and waste will be handled because of the proposed mining activities:

Topsoil

The topsoil from the pit areas will be stripped prior to mining and will be stored on a dedicated topsoil stockpile located in the north western section of the project area. The topsoil stockpile will be 21 ha in size.

Overburden

The overburden (material that lies above the coal such as the hards and softs) generated during the creation of the box cuts (first cut into the overburden to access the coal and interburden) will be stockpiled on the existing Grootegeluk Coal Mine Dump 6.

Interburden

The interburden (material that separates the coal seams within strata) will be transported with the coal to the existing Grootegeluk Coal Mine plants for further beneficiation.

Plant Discard

Discharge from the beneficiation process will report to a common discard conveyor, which will also include the fines discard, from where it will be conveyed to backfill the existing Grootegeluk Coal Mine pit.

Hydrocarbon and hazardous waste

Small amounts of hydrocarbon waste, that includes solid and liquid waste of a petrochemical nature (fuel, grease, oil, etc.) as well as other hazardous waste, will be stored in designated skips or drums for recycling or disposal at a licenced hazardous waste facility in accordance with existing hazardous waste management procedures implemented at Grootegeluk Coal Mine.

General waste

General waste that includes paper, plastic, glass, etc. will be stored in designated containers for disposal in accordance with the Grootegeluk Coal Mine waste management procedures.

2.2.2 Haul Roads

The proposed haul roads will be constructed to tie into the existing Grootegeluk Coal Mine haul roads. The haul roads will connect the Turfvlakte Pit 1, Pit 2, the infrastructure laydown area, topsoil stockpile with the Grootegeluk Coal Mine Dump 6 and the rest of the Grootegeluk Coal Mine operational areas.

The haul roads have been designed to accommodate large off-highway trucks and will be:

- dual carriageway;
- gravel surfaces; and
- 38.2 m wide, allowing for 11m lane widths and 5.4m wide earth berms on the side and in the centre of the road.

2.2.3 Access Roads

Access to the Turfvlakte mining area will be via the existing Grootegeluk Coal Mine access gate. The proposed new access roads will be constructed to tie into the existing Grootegeluk Coal Mine access roads. The access roads will provide access to all the infrastructure areas.

The access roads have been designed to accommodate light vehicles and will be:

- dual directional roads;
- gravel surfaces; and
- 10 m wide.

2.2.4 Infrastructure Laydown Area

The infrastructure laydown area will be 18 ha and will serve as an area for safe parking, offices and equipment storage.

2.2.5 Storm Water Control and Pollution Control Dam

The storm water management control infrastructure will be designed as per the requirements of Regulation 704 under the National Water Act to ensure separation of clean and dirty water catchments.

Cut-off berms and earth canals will be located upstream of the infrastructure areas to divert the clean water run-off around the dirty infrastructure areas. These canals will integrate into the existing Grootegeluk Coal Mine storm water management system.

The contaminated run-off will be collected in concrete-lined channels that will connect with the existing Grootegeluk Coal Mine storm water management system.

2.2.6 Utilities

Potable Water

A potable water tank, with a capacity of 25 m^3, will be constructed to supply potable water for the mining operations. The potable water will be pumped from the existing Grootegeluk Coal Mine potable water system.

Fire Water

A fire water tank, with a capacity of 25 m^3, will be constructed to supply fire water for the mining operations. The fire water will be pumped from the existing Grootegeluk Coal Mine fire water system.

Sanitation

Sewage from the Turfvlakte operations will be transferred to the existing Grootegeluk Coal Mine for treatment at the existing sewage treatment facilities.

Electricity Supply

A substation will be constructed inside the infrastructure laydown area to supply electricity to the mining operations. The substation will be fed from the future Grootegeluk Coal Mine GG1/GG2 33kV switching station as well as directly from the main Eskom 132/33kV substation.

3.0 SPECIALIST STUDY INTRODUCTION

The report provides the current soil characteristics, land capability and land use of the project area (Figure 1). As part of the study, the soils within the project areas where the main mining infrastructural components are proposed, were surveyed during 4 - 8 December 2017. Samples of the modal profiles, specifically of each diagnostic horizon, were submitted to Eco Analytical Laboratory for analysis of the soil properties required for pedological description and classification of soils per the South African Soil Classification Working group.

The study provides an input into the Environmental Impact Assessment (EIA) as required in terms of the Mineral and Petroleum Resources Development Act (MPRDA), Act 28 of 2002 and the National Environmental Management Act (NEMA), Act 107 of 1998. The Acts require the avoidance of pollution and/or degradation of the environment or where neither can be avoided, it is required that the pollution or degradation thereof be minimised or remediated.

3.1 Study Objectives

The objectives of the study were therefore to do the following:

- Conduct a detailed soils assessment on the proposed project mine infrastructure footprint;
- Classify and map the observed soils per the South African Taxonomic Soil Classification System, 1991;
- Map the current land-use within the proposed project mine infrastructure footprint;
- Determine the impacts on soil and land use associated with the project; and
- Propose environmental management actions required for the preservation of local soils (mitigation measures).

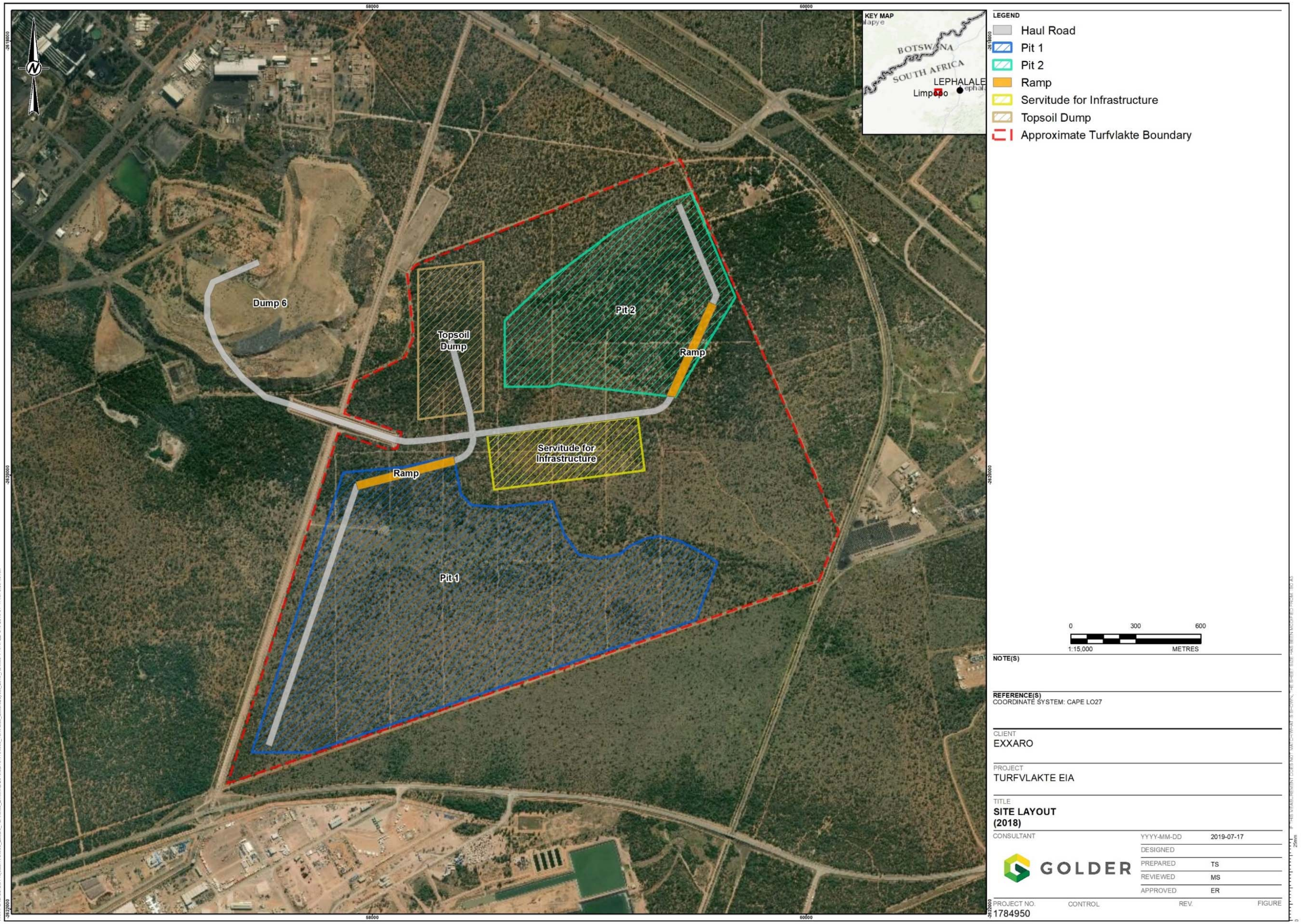


Figure 1: Map of proposed Infrastructure at Turfvlakte

4.0 POLICY LEGAL AND ADMINISTRATIVE FRAMEWORK

The following section outlines a summary of South African Environmental Legislation that needs to be considered for the proposed Turfvlakte mining project in Lephalale with regards to management of soil:

- *The law on Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal;*
- *The Bill of Rights states that environmental rights exist primarily to ensure good health and well-being, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources;*
- *The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely the precautionary principle, the "polluter pays" principle and the preventive principle;*
- *It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source; Soils and land capability are protected under the National Environmental Management Act 107 of 1998, the Environment Conservation Act 73 of 1989, the Minerals Act 50 of 1991 and the Conservation of Agricultural Resources Act 43 of 1983;*
- *The National Veld and Forest Fire Bill of 10 July 1998 and the Fertiliser, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 of 1947 can also be applicable in some cases;*
- *The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided or, where it cannot be avoided, be minimized and remedied;*
- *The Minerals Act of 1991 requires an EMPR, in which the soils and land capability be described; and*
- *The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and watercourses is also addressed*.

5.0 METHODOLOGY

5.1 Desktop study

The desktop study included a review of the historic and recent aerial imagery, evaluating topographic, land cover, land use, land type maps and memoirs, and geological maps of the study area. Review of previous soil reports and soil surveys of the project area were also done. This background information was used to plan and design the field survey.

5.2 Field Survey and Soil Classification

The field survey plan is provided in APPENDIX A. The soil survey was conducted per the standard soil survey techniques. During the field survey the project area was delineated (into map units) and the natural resources, terrain form, soil type and land use of the project area, were recorded. The soil profile observations were evaluated along transects, evaluating the soil at the crest, scarp, midslope, footslope and valley bottom positions of the main geological groups, land types and terrain units of the project area. The shapefiles of the project boundary, existing and proposed infrastructure, surface water features, terrain, geology, landtype, existing land capability and land use were superimposed on google earth imagery and 1:50 000 topographic map sheet to create field maps for the survey. The geographical positions of the observation points were loaded onto a hand-held Global Positioning System (GPS) to aid in field traversing of the positions.

At each observation point, the soil was augered to a depth of 120 cm (unless an impenetrable layer was encountered restricting sampling depth) using a bucket auger. The relevant and distinct soil and landscape features were recorded at each observation point. These included characteristics such as soil colour, texture, soil depth, stoniness, drainage class, parent material, signs of erosion, vegetation cover, micro-topography, aspect and fauna.

For the classification, the soil characteristics were used to classify the soils according to the Taxonomic Soil Classification System for South Africa (Soil Classification Working Group, 1991). The procedure used in the identification of the soil types using the Taxonomic Soil Classification System involved the following:

1. Demarcating the master horizons present in the profile;
2. Identifying diagnostic horizons or materials;
3. Establishing the soil form using the Key in the Classification Book;
4. Identifying family criteria;
5. Establishing the soil family; and
6. Determining the texture class of the A horizon, which was then added to the code of the soil family.

For this study, a set of **33** modal profiles within the project area were described in detail and soil samples of the diagnostic topsoil and subsoil horizons were collected (locations of observation points for the transect walks are presented in Figure 2). The descriptions of **12** test pits advanced during the contaminated land assessment (CLA) study conducted by Golder in 2017 were also described in detail (Refer to Golder report no. 1528677-315855-11 for details).

5.3 Soil Sampling and Analysis

The soil samples were only collected from distinctively different modal profiles comprising of A and B horizons or saprolite and were submitted for laboratory analysis to Eco Analytica laboratory, at the Northwest University in Potchefstroom. The analysis was conducted according to methods set out in the Handbook of Standard Testing for Advisory purposes (Soil Science Society of South Africa, 1990). Soil samples were analysed for the following parameters:

- Three (3) fraction particle size (sand, silt and clay) analysis;
- Ammonium acetate (at pH 7) extractable cations (Ca, Mg, K and Na);
- Walkley- Black Organic Carbon;
- Total Nitrogen (by LECO);
- Bray-1 Phosphorus; and
- pH and EC.

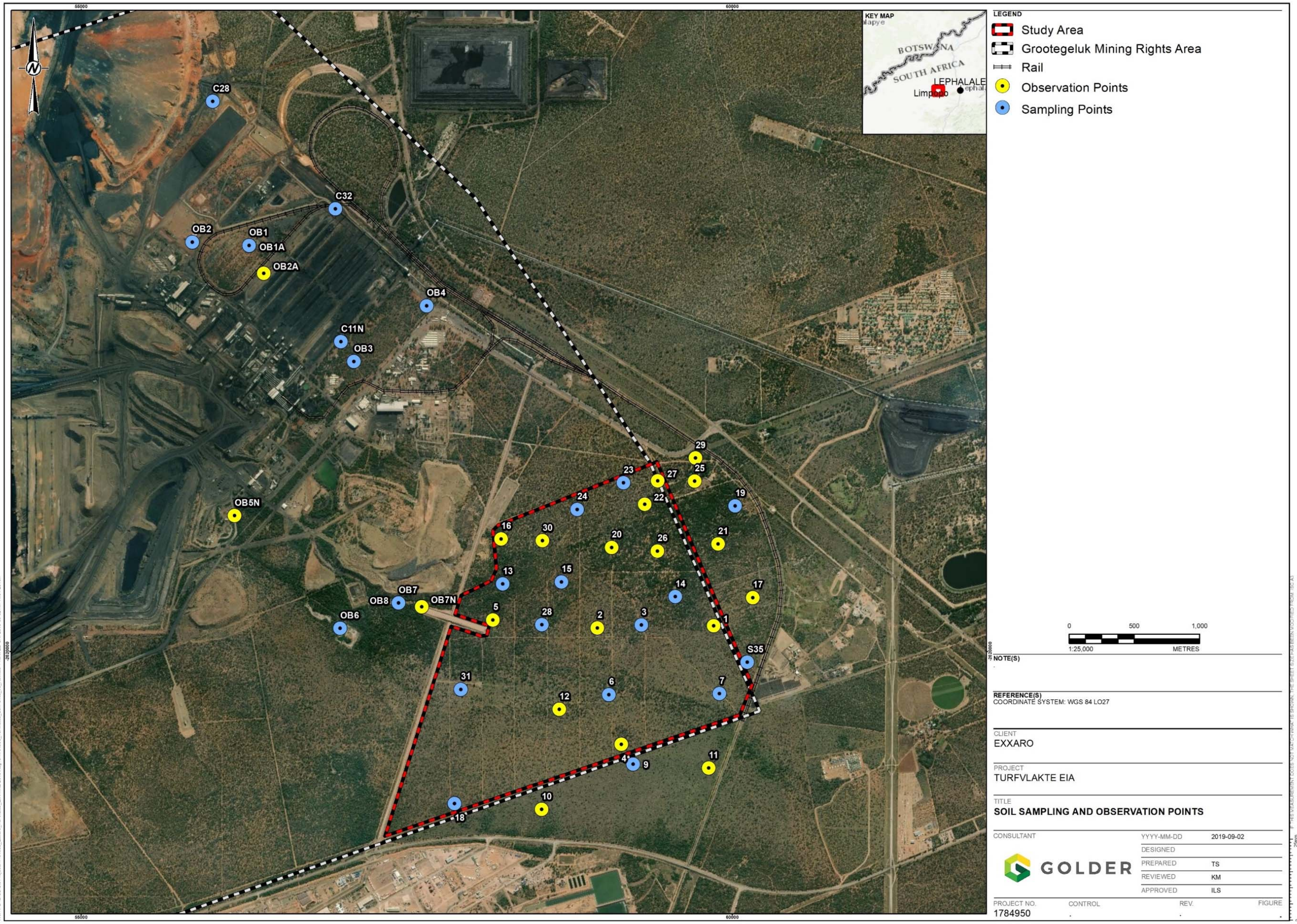


Figure 2: Locations of soil sampling and observation points

5.4 Land Evaluation

5.4.1 Land Capability Classification

The land capability of the proposed footprint was assessed in accordance with the definitions and system outlined by Scotney et al (1987) and updated for South African soils by the Agricultural Research Council (Schoeman, 2000). The criteria used as general guidelines to place soil and land into capability classes are indicated below. This system is based on the Land Capability Classification system of the United States Department of Agriculture (USDA) Soil Conservation Service by Klingelbiel and Montgomery (1961). The soils were classified into eight (**8**) capability classes (Table 1) based on varying limitations (restrictions for rain-fed cropping) of the following soil parameters:

- Effective Depth (D);
- Soil Texture (T).
- Flood Hazard (F);
- Erosion Hazard (E);
- Internal Drainage (W); and
- Mechanical limitations (M).

Table 1: Definition of land capability classes (after Scotney et al. 1987)

Class	General Description
ARABLE LAND SUITABILITY CLASSES	
I	Land has little permanent limitations that restrict the use thereof and has a high potential for intensive crop production.
II	Land has some permanent limitations that lower the degree of intensity of crop production but is still of a high potential.
III	Land has serious permanent limitations that restrict the choice of alternative crops or the intensity of crop production and is of a moderate potential.
IV	Land has very serious permanent limitations that restrict the choice of alternative crops or the intensity of crop production to a great extent.
NON-ARABLE LAND SUITABILITY CLASSES	
V	Land is not suitable for the production of annual crops, but has a slight erosion hazard under natural veld, permanent pastures, forestry or special crops (crops which give sufficient cover and which, with special conservation measures will keep soil losses at an acceptable level).
VI	Land has permanent limitations which make it unsuitable for cultivation and restrict the use of natural veld, forestry and nature life.
VII	Land has such serious limitations that it is unsuitable for cultivation and intensification and the use of the land is therefore limited to natural veld, forestry and nature life.
VIII	Land has permanent limitations that exclude it from commercial plant production and the use thereof is limited to nature life, recreation, water provision and aesthetic qualities.

The land capability of the proposed footprint was compared to the National Land Capability which was refined in 2014- 2016. The National Land Capability methodology is based on a spatial evaluation modelling approach and a raster spatial data layer consisting of fifteen (15) land capability evaluation values (Table 2), usable on a scale of 1:50 000 – 1:100 000 (DAFF, 2017). The previous system is based on a classification approach, with 8 classes (Table 1).

Table 2: National Land Capability Values (DAFF, 2017)

Land Capability Evaluation Value	Land Capability Description
1	Very Low
2	
3	Very Low to Low
4	
5	**Low**
6	Low to Moderate
7	
8	**Moderate**
9	Moderate to High
10	
11	**High**
12	High to Very High
13	
14	Very High
15	

5.4.2 Agricultural Potential Classification

Land Capability Classification (LCC) categorises soils into groups based on the ability to sustain typical cultivated rain-fed crops, which do not require intensive site conditioning or amelioration. The capability classification groups individual soil types (soil mapping units) into groups of similar soils (capability units or classes) based on the criteria for the eight capability classes. Land with higher LCC typically has lower crop production input costs, producing higher yields than land with lower LCC (Singer, 2006). The LCC system thus provides an economic estimation of the soil agricultural capability (or potential). In previous soil specialist studies conducted as part of EIA work, the soil agricultural potential was determined in terms of the land capability classification (Paterson, 2009; Kruger et al, 2009). The soil agricultural potential for this study was determined based on the LCC, by assigning qualitative criteria ratings such as high, moderate, marginal to low (Table 3) to the land capability classes.

Table 3: Criteria for agricultural potential classification

LCC	Soil Agricultural Potential
I – III	High
V – VI	Medium
VII – VIII	Marginal to Low

5.5 Land Use Mapping

The current land use of the study area was mapped and described in accordance to the Spatial Planning and Land Use Management Act (Act No.16 of 2013).

6.0 RESULTS

6.1 Environmental context

Documents appraised as part of the desktop study include the following:

- Digby Wells Environmental. (2014). Grootegeluk Coal Mine Environmental Impact Assessment and Environmental Management Programme (EIA, EMP) Report. Report Number: EXX2678;
- Digby Wells Environmental. (2014). Environmental Impact Assessment for Grootegeluk Coal Mine Railway Loop- Soil Survey Report. Report Number: EXX2678;
- Golder Associates. (2016). Grootegeluk Groundwater Specialist Study. Report Number: 1405692-13532-1;
- Council for Geoscience, Geological Map Sheet 2326 Ellisras, scaled 1:250 000;
- ARC – Institute for Soil, Climate and Water. (2016). Map Catalogue - National Land Capability and Map, scaled 1: 2 500 000; and
- ARC – Institute for Soil, Climate and Water. (2016). Land Type Map sheet 2326 Ellisras, scaled 1: 250 000.

6.1.1 Climate

The Grootegeluk mining operations are situated in the Waterberg region of South Africa which falls within the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent, except for near the surface, is anti-cyclonic throughout the year. The synoptic patterns affecting the typical weather experienced at the mine owe their origins to the subtropical, tropical and temperature features of the general atmospheric circulation over South Africa (Golder, 2016).

The highest temperatures are typically experienced during the summer months of December, January and February, and the lowest during the winter months of June, July and August. Average summer and winter minimum and maximum temperatures are indicated in Table 4 below.

Table 4: Average Summer and Winter Minimum and Maximum Temperatures (Golder, 2016)

Season	Minimum	Maximum
Summer	11°C	40°C
Winter	0°C	28°C

Rainfall

The Grootegeluk Mine is located in the summer rainfall region of South Africa and most rainfall is received between November and April as reflected in Table 2. However, inter-annual rainfall variability is known to occur. Lowest rainfall levels are typically experienced in the month of June and the highest during January. Rainfall is typically experienced in the form of short duration intense convection thunderstorms, leading to occasional flooding. Droughts occur periodically. The mean annual precipitation (MAP) monitored by Grootegeluk between 1980 and 2003 is 441 mm (Golder, 2016). The monthly average rainfall is presented in Table 5 below.

Table 5: Rainfall data as monitored by Grootegeluk Coal Mine (1980 -2003)

Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	MAP
Average precipitation (mm)	1.2	1.4	3.8	37.9	63.1	88.2	77.7	76.4	54.1	25.6	8.8	3.3	441.3

Evaporation

The mean annual Symons-pan evaporation (MAE) near the mine is 1,950 mm (WR90). Mean monthly evaporation values are presented in Table 3. It is to be noted that the MAE is about four times higher than the local mean annual precipitation (MAP) near the mine (Golder, 2016). Table 6 presents the monthly evaporation values for the study area.

Table 6: Mean monthly S-pan Evaporation Values for Grootegeluk Mine Area (Golder, 2016)

Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Average evaporation (mm)	226	210	210	209	174	165	129	110	91	102	137	186	1950

6.1.2 Local Geology

Grootegeluk Mine extracts coal from the Waterberg coalfield (Figure 4). The coalfield extends westwards into Botswana. The Waterberg coalfield covers an area of approximately 88 km (east to west) and 40 km north-south. The coalfield is fault-bounded and forms a graben structure. The Eenzaamheid Fault forms the southern boundary, with rocks of the Waterberg Group occurring to the south and the Karoo to the north. The northern boundary is delineated by the Zoetfontein fault with Archaean granites outcropping north of the fault (Golder 2013).

The coalfield is further subdivided by the Daarby Fault that delineates a shallower, western part of the coalfield, which is suitable for opencast mining and a deep north-eastern part not suitable for opencast mining. The Zoetfontein Fault was tectonically active before and during Karoo deposition, while the Eenzaamheid and Daarby faults - as most of the other faulting in the Waterberg coalfield - are younger than the Karoo sequence.

Sedimentation occurred in a shallow east-west striking trough and the general direction of transport was ENE-WSW. Karoo sediments are deposited on the Waterberg Group in the southern portion of the coalfield, while the basement rocks to the north of the Zoetfontein Fault are Archaean rocks. The paleo-floor in the eastern portion consists of granite and basic rocks of the Bushveld Igneous complex. Relatively few dolerite dykes outcrop in the south-eastern portion of the coalfield and no sills have been intersected in any of the exploration boreholes (Golder 2013).

6.1.3 Topography

The general topography of the Grootegeluk mine lease and surrounding areas which include Turfvlakte project area is described as featureless plains with slopes that vary between 0 and 3%. The natural elevation varies between 900 to 922 m above sea level at Grootegeluk mine and falls to approximately 880 m above mean sea level at the Turfvlakte project area (Golder, 2016). The general drainage direction is towards the north-east to the Moloko River via dry sandy gullies such as the Sandloopspruit (Golder, 2016).

6.1.4 Regional soils, land capability and land use

A reconnaissance landtype survey on a scale of 1:250 000 was conducted in the early 1970`s to compile inventories of the natural resources of South Africa in terms of soil, climate and terrain. The survey highlights the dominant soils in each landtype and their respective percentages. This information is however not a substitute for a detailed soil map but gives a very good indication of where certain soil types occur.

The landtype memoirs and associated maps of 2326 Ellisras, (Peterson and Haarhoff, 1976-2006) indicated that the study area comprises of landtypes Ae252 and Ah85. The Ae252 landtype consists of approximately 84% of the study area, whereas landtype Ah85 occupies of approximately 16%.

The Ae252 landtype comprises 79% of the Hutton soil form and 11% of the Mispah soil form. The Ah85 comprises of 46% of Hutton, 43% Clovelly, 5% Fernwood, 4% Avalon and 2% of the Mispah soil forms respectively.

6.1.5 Land Capability

The land capability classification was undertaken at a national scale, using the landtype data on a scale of 1:250 000 (Schoeman et. al. 2000).

The land capability for the project area, as defined in the National Land Capability for South Africa, is classified as Class V (100%). Class V land is non-arable land only suitable for limited pastoral or forestry (if rainfall is sufficient) use, and generally not suitable for cultivation.

6.2 Field Survey and Soil Classification

The soils observed during the survey were classified according to the Taxonomic Soil system for South Africa (Soil Classification Working Group, 1991). Six different soil forms were identified within the project area and a detailed legend of the observed soil forms is presented in Table 7. The spatial distribution of the observed soils is presented in Figure 3. The soil profile descriptions are provided in 59APPENDIX B.

The Hutton soil form within the Turfvlakte project area represents ~21.85%, Plooysburg soil form represents ~8.29%, Clovelly represents ~12.15%, Addo represents ~0.98%, dry pans represents ~0.44% including a man-made dam (waterbody) representing approximately 0.021% of the total project area. Majority of the area mapped within the Grootegeluk mine comprises of disturbed area representing ~46.53% and partially disturbed area underlain by Hutton soil form representing ~5.07%. A small coverage of the study area within the Grootegeluk mine comprises of Hutton and Plooysburg soil forms which represent ~2.01% and 2.33% respectively.

6.3 Soil Chemical Analysis

A summary of analytical laboratory results of sampled representative soil profiles is presented in Table 8. Laboratory certificates of the analysis are presented in APPENDIX C.

The soil chemical results were evaluated using the guideline for interpretation of soil analysis as outlined in the Fertilizer Society of South Africa's Fertilizer Handbook (2007). The soils have the following soil fertility related properties:

- The soil textures of representative soil forms are predominantly loamy sand to sandy loam. The exception is the Clovelly 1100 family and the soils found in the dry pans which are generally sandy to sandy clay.

- Most of the analysed soil forms (60%) are slightly acidic to alkaline (6.13 < pH < 8.39) except for very acidic to acidic Cv1100 (4.82 < pH < 5.38), very acidic to slightly acidic Hu3100 (4.97 < pH < 6.7), acidic Hu31000 (5.74 < pH < 5.75) and very acidic Hu1100 (4.73 < pH < 4.75). The salinity of all representative soil forms will have no effect on plant growth as the electrical conductivity ($EC_{sat\text{-}paste}$) is less than 200 mS/m;
- The cations status of sandy clay soils found in the dry pans is high (Mg > 300 mg/kg and K > 250 mg/kg). The Ad2111, Hu3100 and Py1000 soil forms generally have a medium (200 mg/kg < Ca < 3000 mg/kg, 40 mg/kg < K < 250 mg/kg and 50 mg/kg < Mg < 300 mg/kg) cation status. The cation status of Hu1100 is low (Ca < 200 mg/kg, K < 40 mg/kg and Mg < 50 mg/kg);
- The concentration of phosphorus (Bray-1) within all soil forms is low (Bray 1 P < 8 mg/kg) and representative of a probable uncultivated land. The medium concentration of P (8-30 mg/kg) are found within the A-horizon (> 8mg/kg) of Hu3100 soil type.

Table 7: Detailed soil map legend of the project area

Soil Map Unit	Master Horizons	Depth (cm)	Brief description	Diagnostic Horizon	Coverage (ha)	Coverage (%)
Hu3100 SaLm Hutton (Hu3100)	A1	0-20	Slightly moist; 100% very dark grey (5YR3/1); fine sandy loam, apedal, gradual smooth boundary	Orthic	394.74	21.64
	B1	20-80	Dry; 100% reddish brown (5YR4/4); fine loamy sand, apedal, moderately compact, gradual smooth boundary	Red apedal		
	B2	80-120	Dry; 100% light reddish brown (5YR6/3); apedal; fine loamy sand	Red apedal		
Hu3200 SaLm Hutton (Hu3200)	A1	0-31	Dry; 100% dark reddish brown (5YR3/2); fine sandy loam, apedal, gradual smooth boundary	Orthic	2.26	0.12
	B1	31-80	Dry; 100% reddish yellow (5YR6/8); fine loamy sand, apedal, with 5-10% small quartz stone; gradual transition	Red apedal		
	B2	80-90+	Dry; reddish yellow (5YR6/8); fine loamy sand, apedal, with 20-30% calcrete nodules and quartz stones	Red apedal		
Hu3100** Sa Hutton (Hu3100)	A	0-20	Slightly moist, 100% dark brown (2.5YR3/6), apedal, fine, sandy loam; gradual smooth boundary	Orthic	36.58	2.01
	B1	20-32	Dry, 100% light brown (2.5YR5/6), apedal, fine, loamy sand; smooth transition	Red apedal		
	B2	32-50	Dry, 100% red (2.5YR4/8), apedal, fine, sand; refusal on hardened soil layer	Red apedal		
Hu1100 Sa Hutton (Hu1100)	A	0-35	Dry; reddish brown (5YR5/4); fine sand, apedal, single grain, gradual smooth boundary	Orthic	1.56	0.09
	B1	35-122	Dry; reddish yellow (5YR6/6); fine sand, apedal, abrupt transition	Red apedal		
	C	122+	Ferricrete	Hard Plinthic		
Cv1100 Sa Clovelly (Cv1100)	A1	0-45	Slightly moist; reddish brown (5YR5/4); fine sand, single grain; smooth transition	Orthic	188.96	10.36
	B1	45-120	Dry; reddish brown (5YR6/6); fine sand, single grain; loose	Yellow-brown apedal		
Cv3100 Clovelly (Cv3100)	A	0-52	Dry; 100% dark reddish brown (5YR5/3); fine loamy sand, apedal; smooth transition	Orthic	32.7	1.79
	B1	52-110	Dry; 100% yellow red (5YR5/8); fine loamy sand, apedal, abrupt transition	Yellow-brown apedal		
	C	110+	Ferricrete	Hard Plinthic		
Py1000 SaLm Plooysburg (Py1000)	A1	0-34	Moist; dark reddish grey (10R4/1); fine loamy sand; single grain; non-hardened free lime; smooth transition	Orthic	151.17	8.29
	B2	34-50	Dry; reddish yellow (7.5YR); fine loamy sand; strongly effervescent calcrete gravel	Red apedal		
	C	50+	Calcrete	Hardpan carbonate horizon		
Py1000** SaLm	A1	0-7	Slightly moist, brown (2.5YR4/6); fine sandy loam with black concretions; smooth transition	Orthic	42.52	2.33
	B1	7-50	Dry; red (2.5YR4/8); apedal, fine sandy loam, gradual transition	Red apedal		

Soil Map Unit	Master Horizons	Depth (cm)	Brief description	Diagnostic Horizon	Coverage (ha)	Coverage (%)
Plooysburg (Py1000)	B2	50-80	Dry; red (2.5YR5/6); apedal, fine sandy clay loam; strongly effervescent calcrete gravel	Red apedal		
	C	80+	Calcrete	Hardpan carbonate horizon		
Ad2111 SaLm Addo (Ad2111)	A1	0-11	Moist; 100% dark greyish brown (10YR4/2); fine loamy sand with small quartz stone; smooth transition	Orthic	17.95	0.98
	B1	11-46	Dry; 100% greyish brown (10YR5/2); fine loamy sand; apedal; with carbonate concretions; effervescent with 10% HCl; gradually smooth boundary	Neocarbonate		
	C	46-120	Dry; 100% light brownish grey (10YR6/2); fine sand; apedal with abundant indurated carbonate concretions; violently effervescent	Soft Carbonate horizon		
Partially Disturbed Areas (Hutton) (Hu3100 Sa)	A	0-30/35	Coal discard	Fill material	92.43	5.07
	B	30/35-110	Dry, 100% red (10R4/6); fine grained, apedal, sand; gradual transition	Red apedal		
	C	110-200+	Highly weathered and friable shale	Saprolite		
Disturbed Areas	Areas with built-up mining infrastructure				848.86	46.53
Existing Road	Existing light and heavy vehicular road				6.45	0.35
Dry Pan	A	0-20	Dry; 100% very dark grey (2.5Y3/1); fine sandy loam; apedal; with yellow mottles; gradual transition	Carbon enriched orthic A	7.99	0.44
	B1	20-50	Dry; 100% very dark grey (2.5Y3/1); fine sandy clay without clearly developed ped surfaces	Carbon enriched orthic A		
Waterbody	Artificial dam				0.13	0.01
Total					**1824.3**	**100**

Table 8: Analytical results of representative soil forms

Soil Form	Sample ID	Master Horizons	Depth (cm)	pH (H_2O)	EC	Ca	Mg	K	Na	P	CEC	OC
					(mS/m)	mg/kg					cmol(+)/kg	%
Hu3100 LmSa	7-1	A	0-20	6.57	24	899.0	99.5	152.5	0.5	5.0	17.79	0.52
	7-2	B1	20-80	7.01	23	1015.0	138.5	125.5	0.5	3.9	12.79	
	7-3	B2	80-120	6.95	41	893.0	166.0	113.5	1.0	3.6	15.77	
	7-4	B3	0-31	7.21	55	1071.5	176.5	191.0	1.5	3.6	23.22	
Hu3100** Sa	OB1-1	A	0-20	6.47	62	1391.0	339.0	161.5	2.0	6.1	18.10	0.74
	OB1-2	B1	20-32	6.93	42	1445.0	261.5	15.0	9.5	4.2	14.74	
	OB1-3	B2	32-50	6.12	46	625.0	99.5	2.0	2.0	4.1	14.79	
Hu3200 SaLm	3-1	A	31-80	5.05	21	320.5	41.5	55.0	0.5	5.2	18.93	0.37
	3-2	B1	80-90+	5.44	12	533.0	77.0	22.0	1.5	3.7	21.85	
	3-3	B2	0-35	6.44	40	1349.0	88.5	4.0	1.0	3.7	14.78	
Hu1100 Sa	24-1	A	35-122	4.75	9	12.0	2.0	1.5	1.0	7.6	14.96	ND
	24-2	B1	122+	4.73	6	7.0	2.0	1.0	1.0	3.8	10.87	
Cv1100 Sa	23-1	A	0-45	5.38	14	78.0	16.5	2.0	1.0	4.8	12.34	ND
	23-2	B1	45-120	4.82	11	11.0	6.5	1.5	1.0	4.1	11.17	
Cv3100 SaLm	15-1	A	0-52	5.75	16	287.0	43.5	68.5	1.0	3.9	15.23	ND
	15-2	B1	52-110	5.74	14	356.5	84.0	54.0	1.0	3.8	16.63	
Ad2111 SaLm	19-1	A	110+	6.57	47	1155.0	226.5	159.0	8.5	6.1	15.73	0.60
	19-2	B1	0-34	7.82	63	1734.5	314.5	70.5	26.5	4.5	17.40	
	19-3	B2	34-50	8.38	71	2856.5	600.5	74.0	52.5	4.0	23.48	
	19-4	C	50+	8.39	77	2833.0	681.0	49.5	85.5	3.4	23.64	
Py1000 LmSa	31-1	A	0-11	7.24	46	1467.0	173.5	225.0	1.5	3.9	18.31	ND
	31-2	B1	11-46	7.58	51	2778.5	198.0	93.0	1.5	3.4	25.75	

Soil Form	Sample ID	Master Horizons	Depth (cm)	pH (H_2O)	EC	Ca	Mg	K	Na	P	CEC	OC
					(mS/m)	mg/kg					cmol(+)/kg	%
Py1000** SaLm	OB4-1	A	0-7	5.72	55	786.5	231.5	126.5	2.0	3.8	19.84	0.58
	OB4-2	B1	7-50	7.09	49	1388.5	238.0	177.5	2.0	5.9	18.18	
	OB4-3	B2	50-80	6.29	52	1264.5	452.5	32.5	4.5	3.6	21.00	
Dry Pan	S35-1	A	46-120	6.13	66	2509.5	476.5	531.0	2.0	7.5	32.26	1.94
	S35-2	B1	0-20	6.43	23	2543.5	549.0	230.5	12.0	4.1	35.14	0.60

Notes: Cations concentrations that are Low are highlighted in **green**, medium **yellow** and high in **orange; ND** – No data; ** - Samples taken within Grootegeluk mine

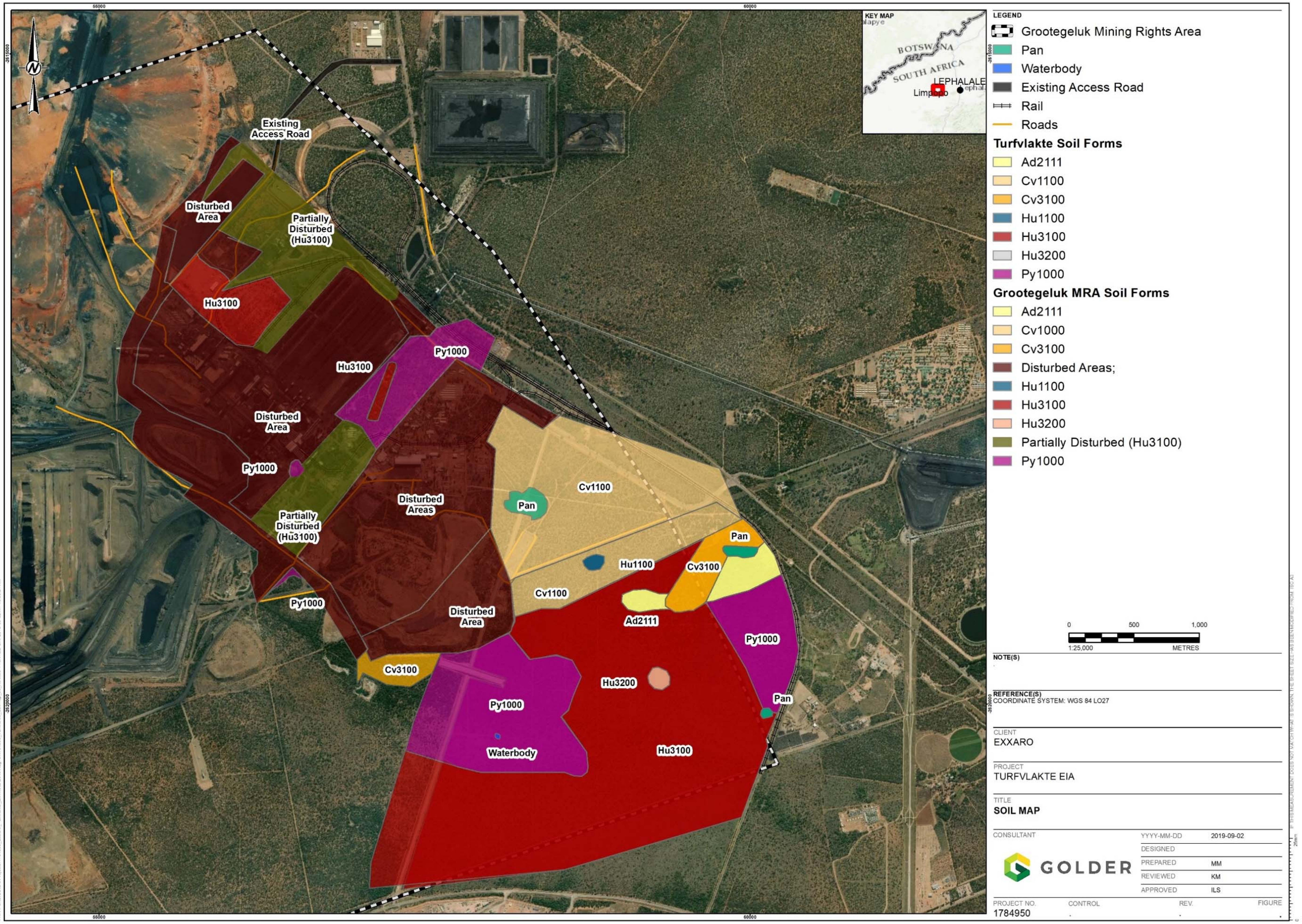


Figure 3: Distribution of different soil types observed at Turfvlakte project area

6.4 Land Evaluation

6.4.1 Land Capability Classification

The land capabilities present in the Turfvlakte project area were assessed in accordance to the methodology outlined in Section 5.4.1. The results from the field observations and the soil properties presented in Table 10 and were compared to the land capability criteria presented in Section 5.4.1. The soil capability and land capability classification are presented in Table 11.

The soil capability classes are derived from the evaluation of terrain (field observations) and soil factors (soil properties). Most soils observed are classified as S_3 due to the moderate to high erosion hazard (E3) except for Plooysburg (Py1000) soil form classified as S_4 due to mechanical limitation (M4). The soil erodibility (K-factor) was estimated as > 0.45 t ha h ha^{-1} MJ^{-1} mm^{-1}, with certain topsoil having higher erodibilities (0.65 t ha h ha^{-1} MJ^{-1} mm^{-1} for certain of the Hutton soils). The calculated soil erodibility indicates that the topsoils are inherently prone to erosion.

For the land capability, the evaluation of the climatic factors alongside the soil capability is required (Note: Land capability, considers the restrictions for rain-fed cropping and thus needs to consider the climatic factors which may limit for rain-fed crop production).

Given the climatic constraints of insufficient rainfall for dryland cropping, the land capability of the project is classified as Class V soils which have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Examples of Class V are:

- “Bottomlands subject to frequent flooding that prevents the normal production of cultivated crops”.
- “Nearly level land with a growing season that prevents the normal production of cultivated crops”.
- “Level or nearly level stony or rocky land”.
- “Ponded areas where drainage for cultivated crops is not feasible but which are suitable for grasses or trees”.

In comparison to the National Land Capability, which indicates that at least 64% of the project area has moderate land capability (Table 9), the local level assessment (this study, Table 11) classified the area has not suitable for the production of annual crops. It r is important to note that the scale (1:50 000 – 1:100 000) of the National Land Capability data is not appropriate for site specific impact assessment. Thus, information obtained from a more detailed field survey (1:25 000): and soil analysis allows for a more refined interpretation of the land capability.

Table 9: National Land Capability rating for Turfvlakte Project area

Land Capability Value	Area (%)	Land Capability Description
5	0%	Low
6	17%	Low to Moderate
7	3%	
8	64%	Moderate
9	16%	Moderate to High

Table 10: Physical properties of representative soils

Soil Code	Sample ID	Master Horizon	Top	Bottom	Slope	Sand	Clay	Silt	Soil texture
Units			cm		%	(%<2mm)			
Hu3100 LmSa	7-1	A	0	12	0-2	88.9	10.3	0.8	Loamy Sand
	7-2	B1	12	45		89.2	7.9	2.9	Loamy Sand
	7-3	B2	45	75		85.7	11.1	3.2	Loamy Sand
	7-4	B3	75	120		86.2	13	0.8	Loamy Sand
Hu3200 SaLm	3-1	A	0	31	0-2	88.9	8.1	3	Loamy Sand
	3-2	B1	31	80		81.5	17.6	0.9	Sandy Loam
	3-3	B2	80	90+		77.1	21.6	1.3	Sandy clay loam
Hu3100** Sa	OB1-1	A	0	20	0-2	83.1	7.7	9.2	Loamy sand
	OB1-2	B1	20	32		90.2	5.4	4.4	Sand
	OB1-3	B2	32	50		91.6	4.6	3.8	Sand
Hu1100 Sa	24-1	A	0	35	0-2	94.2	4.3	1.5	Sand
	24-2	B1	35	122		94.1	4.4	1.6	Sand
Cv1100 Sa	23-1	A	0	45	0-2	96	2.4	1.6	Sand
	23-2	B1	45	120+		94.1	4.4	1.6	Sand
Cv3100 SaLm	15-1	A	0	52	0-2	88.8	5.2	6	Sand
	15-2	B1	52	110		85	8.2	6.7	Loamy Sand
Ad2111 SaLm	19-1	A	0	11	0-2	84.5	9.3	6.2	Loamy Sand
	19-2	B1	11	46		79.7	9.5	10.8	Loamy Sand
	19-3	B2	46	105		76.7	12.1	11.2	Sandy Loam
	19-4	B3	105	120		72.8	14.2	13.1	Sandy Loam
Py1000 LmSa	31-1	A	0	42	0-2	86.3	10.1	3.6	Loamy Sand
	31-2	B1	42	50		84.1	9.6	6.3	Loamy Sand
Py1000** SaLm	OB4-1	A	0	7	0-2	78.1	14.1	7.8	Sandy Loam
	OB4-2	B1	7	50		75.2	12.1	12.7	Sandy Loam
	OB4-3	B2	50	80		71.5	20.1	8.3	Sandy Loam

Notes: ** - Samples taken within Grootegeluk mine

Table 11: Soil capability classification and Land capability classification

Soil Code	Sample ID	Terrain Factors		Soil Factors				Soil Capability Class	Climatic Factors	Land Capability Classes
Units		Erosion hazard (E)	Flood hazard (F)	Effective depth (D)	Texture (T)	Internal drainage (W)	Mechanical Limitations (M)		Effective precipitation & Temperature	
Hu3100 LmSa	7-1	E3	F2	D1	T2	W1	M2	S_3	C5	V
	7-2									
	7-3									
	7-4									
Hu3100 ** Sa	OB1-1	E3	F2	D3	T2	W1	M3	S_3	C5	V
	OB1-2									
	OB1-3									
Hu3200 SaLm	3-1	E3	F2	D2	T2	W1	M2	S_3	C5	V
	3-2									
	3-3									
Hu1100 Sa	24-1	E3	F2	D1	T2	W1	M2	S_3	C5	V
	24-2									
Cv1100 Sa	23-1	E3	F2	D1	T3	W1	M1	S_3	C5	V
	23-2									
CV3100 SaLm	26-1	E3	F2	D1	T1	W1	M2	S_3	C5	V
	26-2									
	26-3									
Ad2111	19-1	E3	F2	D1	T2	W1	M2	S_3	C5	V

Soil Code	Sample ID	Terrain Factors		Soil Factors				Soil Capability Class	Climatic Factors	Land Capability Classes
Units		Erosion hazard (E)	Flood hazard (F)	Effective depth (D)	Texture (T)	Internal drainage (W)	Mechanical Limitations (M)		Effective precipitation & Temperature	
SaLm	19-2									
	19-3									
	19-4									
Py1000 LmSa	31-1	E3	F2	D3	T2	W2	M4	S_4	C5	V
	31-2									
Py1000 SaLm**	OB4-1	E3	F2	D2	T1	W5	M4	S_3	C5	V
	OB4-2									
	OB4-3									

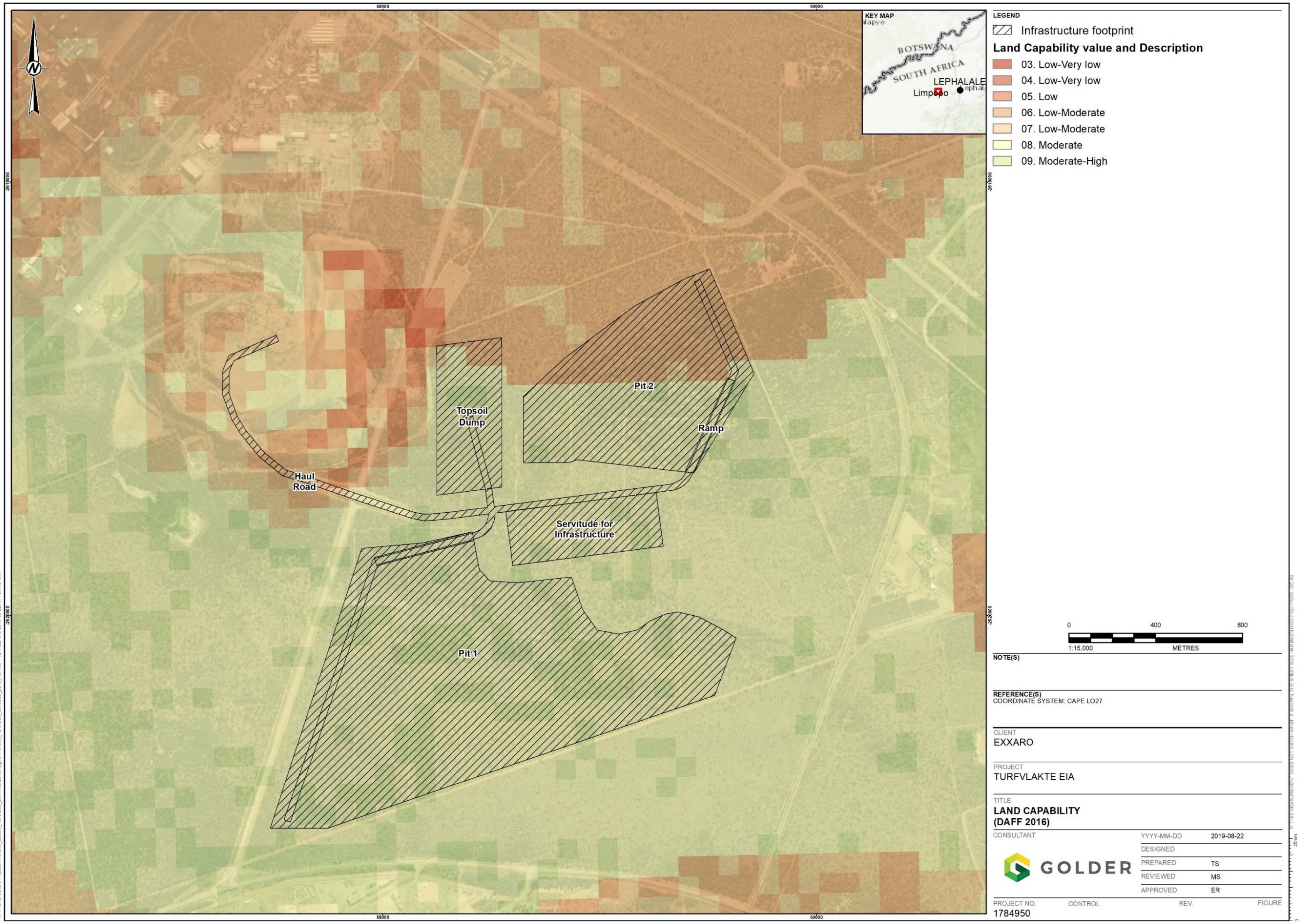


Figure 4: National Land Capability Values for Turfvlakte Project area

6.4.2 Soil sensitivity

Based on the soil survey information and the land capability classification the entire project sites, the soils sensitivity to erosion can be described as having a with moderate sensitivity to water or wind erosion where moderate practices are required to reduce soil loss to acceptable levels (< 10 ton/ha/yr). Given this sensitivity, care should be taken when stripping and handling the soils within the project site. This should be done in order to reduce the extent of soil degradation and quality. Use of machinery typically used in the agricultural industry for soil handling should be considered for soil handling instead of standard mining earth moving equipment.

6.4.3 Soil Agricultural Potential

The results of the LCC shows that most the Turfvlakte project area has medium potential to produce dry land crops. Their use is mainly limited to pasture, range, forestland, or wildlife food and cover. The remaining area which was not assess for LCC includes the artificial dam, dry pans, disturbed and partially disturbed areas comprising ~52.05% of the study area.

6.4.4 Estimated soil availability for rehabilitation actions

Based on the soil classification, soil map and horizon thickness recorded in field, the volume of topsoil and subsoil was estimated. The calculation is based on the life of mine plan for Pit 1 and Pit 2 provided to Golder by Exxaro. At closure, approximately ~ 24 000m^3 of suitable growth medium is needed for the tree stations that will be established at closure. Approximately 2 410 000 m^3 of soil material is also needed for the inside pit shell, to reduce oxygen ingress. The estimated soil requirement for the rehabilitation and closure actions is estimated as ~ 2 434 000m^3. The estimated available soil for rehabilitation is ~1 766 551 m^3. A shortfall of ~ 667 449 m^3 soil was estimated.

Table 12: Estimated volumes of topsoil and subsoil for project infrastructure area

Year	Name	Diagnostic material	First lift (A horizon) cm	Second lift (B horizon) cm	Volume of A horizon (m^3)	Volume of B horizon (m^3)
Year 1	Hu3100	Orthic A & Apedal B	30	90	1391	4172
Year 1	Py1000	Orthic A & Apedal B	30	40	214	286
Year 1	Py1000	Orthic A & Apedal B	30	50	16358	27264
Year 2	Hu3100	Orthic A & Apedal B	30	90	3688	11064
Year 2	Py1000	Orthic A & Apedal B	30	50	371	619
Year 2	Py1000	Orthic A & Apedal B	30	50	20224	33707
Year 3	Hu3100	Orthic A & Apedal B	30	90	4022	12065
Year 3	Py1000	Orthic A & Apedal B	30	40	22683	30244
Year 4	Hu3100	Orthic A & Apedal B	30	90	3405	10216
Year 4	Hu3100	Orthic A & Apedal B	30	90	3947	11841
Year 4	Py1000	Orthic A & Apedal B	30	50	20303	33838

Year	Name	Diagnostic material	First lift (A horizon) cm	Second lift (B horizon) cm	Volume of A horizon (m^3)	Volume of B horizon (m^3)
Year 5	Hu3100	Orthic A & Apedal B	30	90	17970	53909
Year 5	Py1000	Orthic A & Apedal B	30	40	16794	22392
Year 6	Hu3100	Orthic A & Apedal B	30	90	24877	74630
Year 6	Py1000	Orthic A & Apedal B	30	40	9898	13197
Year 7	Hu3100	Orthic A & Apedal B	30	90	42233	126698
Year 8	Hu3100	Orthic A & Apedal B	30	90	40030	120090
Year 9	Hu3100	Orthic A & Apedal B	30	90	38690	116070
Year 10	Hu3100	Orthic A & Apedal B	30	90	42190	126570
Year 11	Hu3100	Orthic A & Apedal B	30	90	30264	90792
Year 12	Cv3100	Orthic A & Apedal B	50	100	5447	10894
Year 12	Hu3100	Orthic A & Apedal B	30	90	11165	33494
Year 13	Ad2111	Orthic A & Neocarbonate B	0	30	0	3029
Year 13	Cv3100	Orthic A & Apedal B	50	100	12768	25536
Year 13	Cv3100	Orthic A & Apedal B	50	100	64	128
Year 13	Hu3100	Orthic A & Apedal B	30	90	21510	64531
Year 13	Hu3100	Orthic A & Apedal B	30	90	38	115
Year 14	Ad2111	Orthic A & Neocarbonate B	0	30	0	10642
Year 14	Cv1100	Orthic A & Apedal B	45	120	1608	4289
Year 14	Hu3100	Orthic A & Apedal B	20	100	19740	98702
Year 15-16	Ad2111	Orthic A & Neocarbonate B	0	30	0	1036
Year 15-16	Cv1100	Orthic A & Apedal B	45	120	6585	17561
Year 15-16	Hu3100	Orthic A & Apedal B	30	90	34614	103841
Total					**473091**	**1293460**

6.5 Land Use

The current land use was delineated as per the information obtained from the recent areal imagery (Google Earth imagery dated 23 June 2017) and field observations. Most of land within the proposed mining areas are used for game farming and farm roads (99%) with the remainder of the area used for transportation (crossing bridge to Grootegeluk mine) and commercial land-use (Manketi Lodge). The land use within the Grootegeluk mine comprises of mining land use.

A summary of land use units counts and associated map units including their approximate spatial extent are presented in Table 13 and shown in Figure 5.

Table 13: Land Use types and approximate percentage occurrences

Map Unit	Primary Land Use	Secondary Land Use	Unit Count	Area (%)
A	Agricultural Purposes	Game Farming and farm roads	1	99
C	Commercial Purposes	Game Lodge	1	0.7
T	Transport Purposes	Overhead bridge crossing	1	0.3
M	Mining Purposes	Mining infrastructure	1	
Total			**3**	**100**

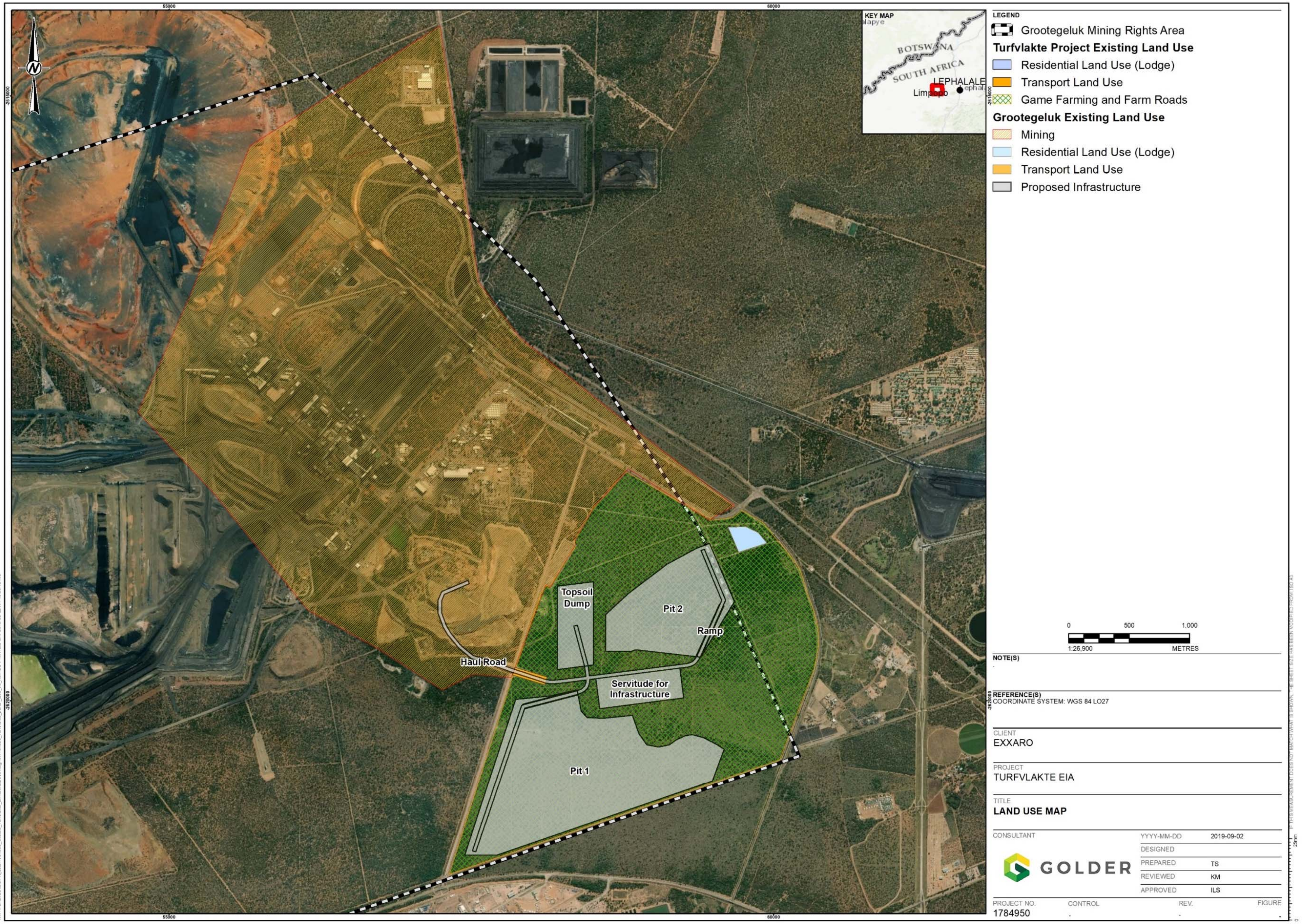


Figure 5: Proposed and Existing land use within the Turfvlakte project area

7.0 ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Methodology for Assessing Impact Significance

The significance of identified impacts was determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Table 14: Impact assessment factors

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude of impact

To assess these factors for each impact, the following four ranking scales are used:

Table 15: Impact assessment scoring methodology

Magnitude	Duration
10- Very high/unknown	5- Permanent (>10 years)
8- High	4- Long term (7 - 10 years, impact ceases after site closure has been obtained)
6- Moderate	3- Medium-term (3 months- 7 years, impact ceases after the operational life of the activity)
4- Low	2- Short-term (0 - 3 months, impact ceases after the construction phase)
2- Minor	1- Immediate
Scale	**Probability**
5- International	5- Definite/Unknown
4- National	4- Highly Probable
3- Regional	3- Medium Probability
2- Local	2- Low Probability
1- Site Only	1- Improbable
0- None	0- None

Significance Points= (Magnitude + Duration + Scale) x Probability.

Table 16: Significance of impact based on point allocation

Points	Significance	Description
SP>60	High environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 - 60	Moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP<30	Low environmental significance	Impacts with little real effect and which will not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

For the methodology outlined above, the following definitions were used:

- Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely-recognised standards are to be used as a measure of the level of impact;
- Scale/Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;
- Duration refers to the length of time over which an environmental impact may occur: i.e. immediate/transient, short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project), or permanent; and
- Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

7.2 Project Phases

The environmental impacts were considered with respect to the Project Description detailed in Section 2.0, with the understanding that the following project activities are anticipated:

7.2.1 Construction phase

- Topsoil is removed prior to mining of the new areas and either stockpiled or transported directly to areas at the mine requiring rehabilitation;
- Construction of laydown areas, parking bays;
- Haul roads connecting the topsoil stockpile area, infrastructure laydown area and pits will be constructed.
- Access roads will be constructed to tie into the existing Grootegeluk Coal Mine access roads;
- A fire water tank and raw water dams will be constructed; and
- Outdoor substation will be constructed at the infrastructure laydown area.

7.2.2 Operational phase

- Diesel driven rotational drills are used to drill the blast holes, before they are primed and blasted.
- The overburden (material that lies above the coal such as the hards and softs) generated during the creation of the box cuts (first cut into the overburden to access the coal and interburden) will be stockpiled on the existing Grootegeluk Coal Mine Dump 6. The interburden (material that separates the coal seams within strata) will be transported with the coal to the existing Grootegeluk Coal Mine plants for further beneficiation.
- Material (product and discard) handling and movement via haul trucks;
- Interburden and coal will be handled at existing GG plants;
- Discard will be backfilled in the existing GG pit.

7.2.3 Closure and rehabilitation phase

Although the objective for final land use is game farming/wilderness it would be unrealistic to assume that the entire disturbed area could be rehabilitated to its original pre-mining state. All facilities will be rehabilitated to a state of physical and chemical stability to ensure safety and to prevent further degradation of the ecological environment (Golder, 2013). The following activities are anticipated during this phase:

- Any mine offices and buildings that are not required for alternative (e.g. community, business or industrial) use will be demolished;
- All infrastructure (as per Turfvlakte layout, Figure 1) will be removed;
- Turfvlakte pits will be backfilled. Final void is anticipated for Pit 1 and Pit 2.
- Project site will be graded to ensure long-term drainage conditions on site; and
- Regrading and revegetation of rehabilitated surfaces to ensure stabilisation of slopes.

7.3 Potential Impacts

The soil processes and relevant soil characteristics were assessed in relation to the activities anticipated during the construction, operation and decommissioning phases of the project. The potential impacts on soils and/or land use that have been identified for the project phases are presented in Table 17 - Table 19. The key soil aspects.

7.3.1 Identified Impacts for the Construction phase

The impacts identified per anticipated activity for the construction phase are listed in Table 17.

Table 17: Anticipated activities and related soil and land use impacts for the construction phase

Anticipated activities	Potential effect on soil and land use
Vegetation clearance as project infrastructure are constructed	■ Loss of **arable land** with land with medium agricultural potential ■ Loss or modification of current **land use** in areas of infrastructure development ■ Loss of soils through **erosion** ■ Loss of **soil nutrients** as a results of vegetation stripping ■ Loss of **soil organic matter** during vegetation stripping.

Anticipated activities	Potential effect on soil and land use
Topsoil stockpiling	■ Loss of soils through **erosion**, particularly for topsoil stockpiles with unvegetated steep slopes ■ Homogenization of soil profiles, i.e. **loss of characteristic horizons.** ■ Loss and/or **reduction in soil biodiversity** in stockpiled soil. ■ Loss of **soil nutrients**, particularly for unvegetated topsoil stockpiles. ■ Loss of **soil organic matter** due to increased aeration (caused by soil disturbance) and subsequent organic matter decomposition. ■ **Modification** of existing **landscape** and **hydrological regimes**.
Construction of access roads, haul roads, stockpile area, laydown areas and substation	■ **Burial of soil** / covering of soils by camp accommodation facility, haul roads, mine waste facilities and processing plant. ■ **Soil compaction** in areas where active heavy machinery will be mobilised for the development of the accommodation facility, mine infrastructure and associated utilities. ■ Increased run-off (and **erosion**) in compacted areas and **modification of natural infiltration**. ■ **Soil contamination** from hydrocarbon and chemical spills including sterilisation by cement pollutants.
Transportation and use of equipment	■ Increased **soil compaction** and run-off at equipment and machinery laydown areas. ■ **Soil contamination** from hydrocarbon spills at equipment and machinery laydown areas; and vehicle workshop.

7.3.2 Identified Impacts for the Operational phase

The impacts identified per anticipated activity for the operational phase are listed in Table 18.

Table 18: Anticipated activities and related soil and land use impacts for the operational phase

Anticipated activities	Potential effect on soil and land use
Open pit development Drilling and blasting	■ **Change in Land use** ■ **Soil disturbance** due to excavation activities at pit location as well as in surrounding soils. ■ Loss of potentially **arable land**. ■ Modification of **natural soil hydrological** regimes; ■ *Potential effects on soil and land use with the development of the open pit may be similar to what is anticipated for construction phase.*
Hauling of coal and waste rock for storage in their respective storage facilities.	■ **Soil contamination** from hydrocarbon spills from vehicles; and ■ **Soil contamination** from spillage/poor handling of product and waste rock outside the designated areas.
Progressive rehabilitation of facilities and areas which are no longer in use	■ **Soil disturbance** due to earth moving activities; ■ **Loss of soil organic matter** due to increased aeration (caused by soil disturbance) and subsequent organic matter decomposition.
Transportation (hauling) of product and waste rock	■ **Soil contamination** from spillage/poor handling of product and waste rock outside the designated areas.
Transportation and use of equipment	■ Increased **soil compaction** and run-off at equipment and machinery laydown areas; ■ **Soil contamination** from hydrocarbon spills at equipment and machinery laydown areas; and vehicle workshop;

7.3.3 Identified Impacts for the Decommissioning Phase

The impacts identified per anticipated activity for the decommissioning and closure phase are listed in Table 19.

Table 19: Anticipated activities and related soil and land use impacts for the decommission and closure phase

Anticipated activities	Potential effect on soil and land use
Removal of redundant infrastructure	■ Spillage of chemical solutions during the dismantling of plant equipment, pipelines or pumps which were in

Anticipated activities	Potential effect on soil and land use
	contact with chemicals solution may **contaminate the soils**; ■ Spillage of diesel, oils and greases from the dismantled plant equipment, resulting in hydrocarbon contamination of exposed soils. (**soil contamination**)
Backfilling of Turfvlakte Pits	■ Spilling of backfill material during haulage outside the designated areas. (**soil contamination**)
Grading of project site to ensure long-term drainage conditions on site	■ **Soil compaction** in areas where active heavy machinery will be mobilised for the shaping of the final landform; and ■ **Loss of soil organic matter** due to increased aeration (caused by soil disturbance) and subsequent organic matter decomposition.
Soil placement and revegetation of project site, including reinstatement of seasonal pans	■ Soil handling to convey soil from topsoil stockpile to project site for surface rehabilitation activities, may result in **degradation of soil quality** due to soil disturbance. ■ **Contamination** of soil by handling of soil with contaminated earth moving machinery (machinery previously used for handling mine waste such as waste rock or tailings material).

7.3.4 Soil aspects impacted

The key soil and land use aspects affected due to the project activities are soil quality degradation, loss of soil as a resource, land use change, soil contamination, soil compaction and soil erosion.

Degradation of soil quality

Soil is degraded when it partially or totally loses its capacity to support vegetation productivity. Land degradation means that the soil has lost the capacity to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water quality, and support human health and habitation. The vegetation removal and soil disturbance expected during the construction phase will result in the disruption of the nutrient cycling process in the soil, i.e. the source of organic matter (vegetation, debris) is removed with a subsequent reduction in soil biodiversity. Overall the significance of the impact of soil degradation is rated as high during the construction phase due to the nature of activities occurring during this phase. With appropriate mitigation measures, the significance of this impact can be moderate.

Loss of soil as a resource (burial of soil) and land use change

With development of mining infrastructure and open pits, there will be loss the current land use to mining. During the construction phase, the land and soils within the project area gradually be covered by the mine infrastructure. Therefore, during the construction and operation phase the impact on soil as a resource and land use is high since the soil will covered and land use changed to mining. However, during the closure and decommissioning phase, the land use will be returned to use for game/wild life. The impact on land use during the closure phase is thus low if the rehabilitated land surface is able to sustain the required game/wild life carrying capacity.

Soil contamination

The contamination of soil from spillages of organic hydrocarbons is likely to occur as heavy mobile equipment typically use these chemicals. Contamination especially along the plant area is also anticipated. The contamination of topsoil from cement mixing is also anticipated during the construction phase. These contaminants are likely to leach into the soil resulting into the sterilisation of the soil. Soil contamination will minimise the land suitability for other land uses outside of industrial or mining due to the potential human health risk associated with contaminated soils. The impact significance is considered medium -low, given the effect will be localized and has the potential to be long-term if contaminants are not removed or contained. With appropriate mitigation measures, the significance of this impact can be low.

Soil compaction

This occurs when the soil particles and porous network within are rearranged as a result of pressure applied on the surface. The soil is expected to be more prone to compaction if soil handling and stripping takes place when the soil is in a moist state. Areas where the mine infrastructure will be constructed will have more active compaction due to the increased use of vehicles and heavy machinery during the construction phase. The impact significance is considered low, given that the effect will be localized and restricted to access roads, vehicle hardstand areas and equipment and machinery laydown areas.

Soil erosion

During the construction phase, areas which were initially covered with vegetation will be exposed, resulting in the increased susceptibility of the soils to erosion. This effect is more pronounced when vegetation is removed, and the soil is left bare during the rainy season, or for stockpiled soils (with steep slopes, sideslopes steeper than 1 in 3) which have not been vegetated before the start of the rainy season. The majority of the land has a moderate hazard to water erosion, though the soils are inherently prone to erosion. Given the disruptive nature of the earth moving activities anticipated during the construction and decommissioning phases, the soil characteristics controlling the soil erodibility (soil organic matter content, structure and permeability) are likely to be altered. The significance of the impact of soil erosion is rated as high during the construction and decommissioning phases. With appropriate mitigation measures, the significance of this impact can be moderate.

Table 20: Impact on soil and land use significance ratings

ACTIVITY *whether listed or not listed. (E.g. Excavations, blasting, stockpiles, discard dumps or dams, Loading, hauling and transport, Water supply dams and boreholes, accommodation, offices, ablution, stores, workshops, processing plant, storm water control, berms, roads, pipelines, power lines, conveyors, etc…etc…etc.).*	POTENTIAL IMPACT *(e.g. dust, noise, drainage surface disturbance, fly rock, surface water contamination, groundwater contamination, air pollution etc.…etc…)*	ASPECTS AFFECTED	PHASE In which impact is anticipated *(e.g. Construction, commissioning, operational Decommissioning, closure, post-closure)*	Magnitude	Duration	Scale	Probability	Significance	Significance without Mitigation	Magnitude	Duration	Scale	Probability	Significance	Significance with Mitigation	Detailed Mitigation Measures	Mitigation Type (Modify, remedy, control or stop) *e.g. Modify through alternative method; Control through noise control; Control through management and monitoring; Remedy through rehabilitation*	Time period for implementation *(time period when the measures in the environmental management programme must be implemented Measures must be implemented when required)*	Standards to be Achieved *(Impact avoided, noise levels, dust levels, rehabilitation standards, end use objectives etc)*	Compliance with Standards *(A description of how each of the recommendations made, will comply with any prescribed environmental management standards or practices that have been identified by Competent Authorities)*	Responsible person
Vegetation clearance as project infrastructure are constructed	Disturbance of soil, resulting in increased decomposition of soil organic matter from topsoil.	Soil degradation	Construction Phase	10	5	1	5	80	High	10	4	1	4	60	Moderate	Procedures on land clearance, soils handling and rehabilitation plan to be adhered to.	Control	Construction phase	As per Exxaro Land Clearance Procedure Soils Stripping and Handling Recommendations(see Section 8.3.6)		Environmental Manager

Soil stripping and stockpiling	- Loss of soils through erosion, particularly for topsoil stockpiles with unvegetated steep slopes - Homogenization of soil profiles, i.e. Loss of characteristic horizons. - Loss and/or reduction in soil biodiversity in stockpiled soil. - Loss of soil nutrients, particularly for unvegetated topsoil stockpiles. - Loss of soil organic matter due to increased aeration (caused by soil disturbance) and subsequent organic matter decomposition. - Modification of existing landscape and	Soil degradation	Construction Phase	10	5	1	5	80	High	10	4	1	4	60	Moderate	Make sure that the results from the pre-mining soil survey are used effectively for the stripping phase to lead to optimal stockpiling. Ensure that there is participation by a soil scientist in the stripping and stockpiling process. Limit vehicle traversing on stockpiles Implement concurrent rehabilitation measures for soils and protect soil stockpiles from erosion by utilising soils erosion procedures. Minimise stockpile height to <3 m. Re-use stockpiled soil within as short a period as possible (within 3-5 years). Strip and stockpile soils from seasonal pans separately, ideally in a similar landscape position was it's orgin, i.e. valley bottom	Control	As required during soil stripping & stockpiling	Stockpile height not exceeding 3 m, where practically possible. Re-use stockpiled soil within as short a period as possible (within 3-5 years)- as per Coaltech Research Association NPC Project 8.2.6 June 2016 report.	Coaltech Research Association NPC Project 8.2.6 June 2016 report	Environmental Manager

	hydrological regimes.																				
Construction of access roads, haul roads, stockpile area, laydown areas and substation	Burial of soil / covering of soils by camp accommodation facility, haul roads, mine waste facilities and processing plant. Soil compaction in areas where active heavy machinery will be mobilised for the development of the accommodation facility, mine infrastructure and associated utilities. Increased run-off (and erosion) in compacted areas and modification of natural	Soil availability Soil quality	Construction Phase	10	5	1	5	80	High	6	4	1	5	55	Moderate	Final Project infrastructure, laydown and access areas will be clearly indicated in final construction plans provided to contractors/employees. The plans will consider environmental (soils) constraints. Access roads (etc.) will be planned to avoid sensitive areas. Contractors (in particular heavy machinery) will be restricted to designated areas as defined by the Environmental Department. Tracked vehicles will be utilised in soil clearance activities as per soil stripping and handling procedures. The extent of the fenced area will be minimised. Procedures on land clearance, soils handling and rehabilitation plan to be adhered to. Pre-clearance permits will be required prior to site clearance activities, which will be monitored by environmental personnel.	- Control through management of construction activitis on areas allocated for new infrastructure. Ensure that activities only occur in designated areas.	During project	Contaminant levels below SSV2 (GNR. 331. Norms and Standards for Remediation of Contaminated Land & Soil Quality)	GNR. 331. Norms and Standards for Remediation of Contaminated Land & Soil Quality	Environmental Manager

	infiltration. Soil contamination from hydrocarbon and chemical spills including sterilisation by cement pollutants.																			
Transportation and use of equipment - potential spills of chemicals (e.g., hydrocarbon). Soil contamination on adjacent land potentially occurring due to inappropriate waste disposal and potential oil and diesel leakages from vehicles and machinery	Contamination of soils by hydrocarbon pollutants. Increased soil compaction and run-off at equipment and machinery laydown areas;	Soil contamination Soil compaction	Construction Phase	10	5	1	3	48	Moderate	6	2	1	2	18	Low	- All vehicles and machinery shall be kept in good working order and inspected on a regular basis for possible leaks and shall be repaired as soon as possible if required; - Repairs shall be carried out in a dedicated repair area only, unless in-situ repair is necessary as a result of a breakdown; - Drip trays shall at all times be placed under vehicles that require in-situ repairs; - Drip trays shall be emptied into designated containers only and the contents disposed of at a licenced hazardous material disposal facility; - Accidental spills (concrete, chemicals, process water, hydrocarbons, waste) need to be reported immediately so that effective remediation and clean-up strategies and procedures can be implemented; - Soil that is contaminated by fuel or oil spills, for example, from vehicles, will be collected to be treated at a pre-determined and dedicated location, or will be treated in situ, using sand, soil or cold cole-ash as absorption medium. Soil compaction during construction and decommissioning phases cannot be avoided as heavy machinery will be operational in all areas where disturbance is anticipated.	- Identify areas where the soil was impacted. - Control through management or remediation options.- Prevent by restricting spillage from construction vehicles; - Control by implementation of storm water management measures; - Remedy by treatment of contaminated soils.	During project	Contaminant levels below SSV2 (GNR. 331. Norms and Standards for Remediation of Contaminated Land & Soil Quality)		Environmental Manager

Open pit development, drilling and blasting	Loss/ Change of current land use. Soil disturbance due to excavation activities at pit location as well as in surrounding soils. Modification of natural soil hydrological regime. Loss of potentially arable land. (*Potential effects on soil and land use with the development of the open pit may be similar to what is anticipated for construction phase*)	Land use Soil quality	Operation Phase	10	5	1	5	80	High	10	5	1	5	80	High	Impact remains high during this phase					
Hauling of coal and waste rock for storage in their respective storage facilities.	Soil contamination from hydrocarbon spills from vehicles; and Soil contamination from spillage/poor handling of product and waste rock outside the designated areas.	Soil quality	Operation phase	10	5	1	5	80	High	6	4	1	2	22	Low	Implement suitable measures on mining infrastructure such as the Product and Waste rock Stockpile areas, PCD's to minimise soil contamination by controlling seepage and runoff; Implementing regular site inspections for materials handling and storage.	Reduce through eliminating contaminant source	During project	Impact avoided		Environmental Manager

Spills of chemicals (e.g., hydrocarbon) .Soil contamination on adjacent land potentially occurring due to inappropriate waste disposal and potential oil and diesel leakages from vehicles and machinery	Contamination of soils by hydrocarbon pollutants	Soil contamination	Operational Phase	4	5	1	3	30	Moderate	6	2	1	2	18	Low	- Accidental spills (concrete, chemicals, process water, hydrocarbons, waste) need to be reported immediately so that effective remediation and clean-up strategies and procedures can be implemented; - Soil that is contaminated by fuel or oil spills, for example, from vehicles, will be collected to be treated at a pre-determined and dedicated location, or will be treated in situ, using sand, soil or cold cole-ash as absorption medium.	- Identify areas where the soil was impacted. - Control through management or remediation options.- Prevent by restricting spillage from construction vehicles; - Control by implementation of storm water management measures; - Remedy by treatment of contaminated soils.	During project	Contaminant levels below SSV1	Rehabilitation standards/objectives	Environmental Manager
Removal of redundant infrastructure	Spillage of chemical solutions during the dismantling of plant equipment, pipelines or pumps which were in contact with chemicals solution may contaminate the soils; Spillage of diesel, oils and greases from the dismantled plant	Soil contamination	Decommissioning & Closure Phase	6	4	3	3	39	Moderate	4	2	1	2	14	Low	Ensure proper handling of hazardous chemicals and materials (e.g. fuel, oil, cement, concrete, reagents, etc.) as per their corresponding Safety Data Sheets (SDS); Dismantling of plant equipment and machinery should be carried out in designated appropriate facilities fitted with spillage containment, floors and sumps to capture any fugitive oils and greases. Develop detailed procedures for spills containment and soils clean up. Conduct soil assessment to determine post decommissioing/closure soil quality on rehabiliated infrastructural footprint	Control through minimzing occurance of contaminant source	Decommissioning & Closure Phase	Contaminant levels below SSV1	Rehabilitation standards/objectives; GNR 331.	Environmental Manager

	equipment, resulting in hydrocarbon contamination of exposed soils.																				
Backfilling of Turfvlakte Pits	Spilling of backfill material during haulage outside the designated areas.	Soil quality (contamination)	Decommissioning & Closure Phase	6	4	3	3	39	Moderate	4	2	1	1	7	Low	Ensure proper handling and transportation of backfill material	Control through minimzing occurance of contaminant source	Decommissioning & Closure Phase	Contaminant levels below SSV2	Rehabilitation standards/objectives; GNR 331.	Environmental Manager
Grading of project site to ensure long-term drainage conditions on site	Soil compaction in areas where active heavy machinery will be mobilised for the shaping of the final landform; and Loss of soil organic matter due to increased aeration (caused by soil disturbance) and subsequent organic matter decomposition.	Soil compaction Soil quality Soil erosion	Decommissioning & Closure Phase	8	5	1	5	70	High	6	4	1	3	33	Moderate	Re-use stockpiled soil within as short a period as possible (within 3-5 years). Use appropriate soil handling machinary (NOT heavy earth moving equipment used for mining operations) to minimize compaction Limit vehicle traversing on both stockpiles and rehabilitated areas as far as possible. Prepare rehabilitated areas properly and monitor regularly. Ensure that the newly created soil profile is free draining (except in re-instated seasonal pan areas)	Control through management and monitoring	Decommissioning & Closure Phase	End land form objectives	Rehabilitation standards/objectives;	Environmental Manager

Soil placement and revegetation of project site	Soil handling to convey soil from topsoil stockpile to project site for surface rehabilitation activities, may result in degradation of soil quality due to soil disturbance. Contamination of soil by handling of soil with contaminated earth moving machinery (machinery previously used for handling mine waste such as waste rock or tailings material). Insufficient soil volumes to meet end land use soil requirements.	Land use Soil quality Soil quantity	Decommissioning & Closure Phase	8	5	1	5	70	High	6	4	1	3	33	Moderate	Re-use stockpiled soil within as short a period as possible (within 3-5 years). Use appropriate soil handling machinery (NOT heavy earth moving equipment used for mining operations) to minimize compaction Limit vehicle traversing on both stockpiles and rehabilitated areas as far as possible. Prepare rehabilitated areas properly and monitor regularly. Ensure that the newly created soil profile is free draining (except in re-instated seasonal pan areas). Consider topsoil cover thickness similar to pre-mining topsoil depths (60% of project footprint has an average topsoil thickness of 20 cm). Stockpile topsoil and subsoil horizons separately and maintain stockpile soil quality.	Control through management and monitoring	Decommissioning & Closure Phase	End land use objectives	Rehabilitation standards/objectives;	Environmental Manager

7.4 Residual impacts

The following impacts remain of moderate significance due to the nature of the activities:

- Soil degradation due to vegetation clearance and soil disturbances (initial stripping, and soil placement during rehabilitation phase); and
- Insufficient soil available for surface rehabilitation.

7.5 Cumulative impacts

With the expected soil degradation occurring, a decline in the overall soil quality and health, may hinder the soil suitability for the end land use.

8.0 ENVIRONMENTAL MANAGEMENT PROGRAMME

This Environmental Management Programme (EMPr) addresses the management of potential environmental impacts related to the proposed road realignment project. The EMPr is used for managing, mitigating, and monitoring of the environmental impacts associated with construction, operational and rehabilitation phases of the realigned route.

8.1 Objectives

- Manage soil quality during the project phases.

8.2 Environmental Management and Mitigation Measures Identified

A summary of mitigation measures should be presented:

- For negative impacts (either / or):
  - Avoid;
  - Minimize;
  - Rehabilitate/Repair; or
  - Compensate;
- For positive impacts:
  - Enhance.

8.3 Summary of Mitigation and Management measures for the Operational, Decommissioning and Closure phases

8.3.1 Degradation of soil quality

To mitigate land degradation impacts:

- **Avoid**:

Minimise the Project footprint.

- **Reduce:**
  - Minimize surface footprints to the extent possible and restrict heavy machinery and heavy truck access to sensitive soil areas, such as the pan areas. Utilization of lighter machinery for the soil handling is also recommended to minimize the impact on physical soil degradation. Here lighter machinery refers to machinery typically used in the agricultural industry for soil handling.

  - Minimize soil contamination through suitable measures for containment and handling of potentially polluting materials and implement Acid Rock Drainage and Metal Leaching mitigation measures.
- **Restore:**
  - Implementing soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation and maintaining soil fertility of topsoils stored for future rehabilitation);
  - Ensuring that the overall thickness of the soils utilised for rehabilitation is where possible consistent with surrounding undisturbed areas and future land use;
  - Landscaping disturbed areas (other than permanent disturbances such as pit voids) to restore where possible back to original contours and drainage lines;
  - Designing slopes to an appropriate gradient for rehabilitation as defined in the Closure Plan; and
  - Basing the soil fertilizing programs on the soil chemical, biological and physical status after topsoil replacement.
- **Compensate:**

None.

- **Enhance**

None

- **Monitoring:**
  - Environmental auditing to verify contractor compliance and soils handling and rehabilitation procedures being implemented.
  - Chemical, biological and physical monitoring of potentially affected soils.
  - Assessment of soil fertility of soil stockpiles before soils use placed for site rehabilitation. Following the establishment of recommended vegetation, monitor soil health (biological, chemical and physical status) until the created soil health supports the recommended vegetation and end land use.

8.3.2 Loss of soil as a resource and land use modification

The potential negative impacts relating to this impact can be mitigated as follows:

- **Avoidance measures:**
  - Minimise the project footprint and therefore disturbance to the minimum area necessary by forward planning (clearing land during the dry season rather than wet season) and clear demarcation of the areas to be disturbed;
  - Avoid permanently impacting topsoil and subsoil, but salvaging the maximum depth of these when clearing areas for infrastructure; and
  - Minimise the extent of the restricted access area to allow for current land use practices (where practically safe to do so).
- **Reduction measures:** As land uses of a specific area in terms of productive farming are largely determined by soil properties, mitigation controls should be put in place such as:
  - Use lighter machinery with lower potential to compact soils when working in areas containing sensitive/productive soils;

  - Avoid mixing topsoil (A-horizon) with subsoil (B-horizon) during stripping and storing of soil;
  - Inform relevant personnel regarding the handling of soils intended for rehabilitation and consider demarcating and indicating areas intended for stockpiling of topsoil and subsoil with signage or noticeboard.
  - Strip and stockpile topsoil together with vegetation to enable continuation of the biogeochemical cycle, thereby preserving fertility;
  - Limiting the stockpile side slopes to 1 in 4 (or gentler where practically possible), and rounding the top edges;
  - Place a runoff containment berm down-gradient of the stockpile to capture runoff, let the transported soil settle and recover it;
  - Keep the stockpile moist to reduce wind erosion and facilitate vegetation growth, until vegetation has established;
  - Vegetate topsoil stockpile with locally indigenous grasses and forbs to maintain biological processes, stabilise the soil and reduce soil loss due to erosion;
  - Regular weeding.
- **Restoration measures:**
  - Implementing soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation);
  - Storing stripped topsoil and subsoil for future site rehabilitation activities;
  - Maintaining soils fertility for future rehabilitation;
  - In case of soil compaction during rehabilitation, ripping is recommended with the addition of fresh organic matter for the restoration of soil structure; and
  - Ensuring that the overall thickness of the soils utilised for rehabilitation is consistent with surrounding undisturbed areas and future land use.
- **Enhance**:
  - Identify and investigate sustainable land use options within the mine footprint and adjacent communities; and
  - Promote sustainable land use and agricultural practices in the project area and adjacent areas.
- **Monitoring mechanisms**:
  - Environmental auditing to verify employee/contractor compliance and soils handling and rehabilitation procedures being implemented;
  - Soil fertility monitoring of stockpiles; and
  - Soil assessment and land capability. Determination of chemical, biological and physical status of rehabilitated soils.
  - Soil erosion assessment of cleared areas, collection and transfer of soil/silt from drainage lines etc.

8.3.3 Soil contamination

- **Avoid**
  - Ensure proper handling and storage of hazardous chemicals and materials (e.g. fuel, oil, cement, concrete, reagents, etc.) as per their corresponding Safety Data Sheets (SDS);

- Maintenance of vehicles and equipment should be carried out in designated appropriate facilities fitted with spillage containment, floors and sumps to capture any fugitive oils and greases.;

- **Reduce**
  - Eliminate fire as a site clearance activity and establish fire breaks to minimise potential soil contamination and protect site areas;
  - Implement suitable measures on mining infrastructure such as the TSF and WRDs to minimise soil contamination by controlling seepage and runoff;
  - Implementing regular site inspections for materials handling and storage as well as pipeline monitoring.
- **Restore**
  - Development of detailed procedures for spills containment and soils clean up.
- **Compensate**

Not applicable.

- **Enhance**

Not applicable.

- **Monitoring mechanisms:**
  - Environmental inspections and auditing; and
  - Soils sampling and analysis as part of spills/contamination procedures and as per soils monitoring program around mining infrastructure.

8.3.4 Soil compaction

Soil compaction during construction and decommissioning phases cannot be avoided as heavy machinery will be operational in all areas where disturbance is anticipated. The compaction of soil will be limited to project footprint. Where possible the following should be implemented:

- Soil should be stripped in a dry state and not in a moist or wet state;
- Loosening of the soil through ripping and discing prior to the stripping process is recommended to break up crusting;
- A secondary cultivation may be required to break up large clods;
- Unnecessary trafficking and movement over the areas targeted for construction must be avoided, especially heavy machinery; and
- Regular dust suppression with uncontaminated water should be practiced avoiding elevated dust generation especially along residential areas.

8.3.5 Soil erosion

Erosion control measures need to be defined in the Land Clearance Form. The specific actions must indicate how the following recommendations will be implemented:

a) Work should be stopped in land clearance areas during heavy rainfall periods

b) Drainage channels must be developed as per the stormwater management plan and maintained. Drainage channels and soakaways must direct runoff away from cleared areas, but not into streams or rivers;

c) Sediment deposited in drainage channels and sediment ponds must be removed prior to the rainy season or when channels are deemed to be full.

d) All sediment deposited from erosion events needs to be placed on the topsoil stockpile(s);

e) Provide adequate road drainage based on climate, road width, surface material, compaction, and maintenance.

f) Limit access road gradients to reduce runoff-induced erosion.

g) Increase vegetation cover upwind of cleared and exposed areas such as the Waste Rock facility, Tailings Storage facility and Plant areas.

h) Soil stockpiles must be developed as per the Exxaro Soil Stripping and Handling Guide (if available).

i) Topsoil and Subsoil stockpiles must be vegetated once the final stockpiles are constructed;

j) Ripping, replacing soils and revegetating closed areas such as access roads and lay down areas following completion of construction works; and

k) Periodic erosion monitoring to be undertaken in cleared areas.

Additional optional erosion control measures

Should erosion be evident or potentially likely, the following additional erosion controls can be utilised:

- Contouring and minimizing length and steepness of slopes;
- Mulching (applying organic materials) to stabilize exposed areas;
- Lining steep channels and slopes (e.g. use jute matting);
- Reducing or preventing off-site sediment transport through use of settlement ponds or silt fences;
- Consideration needs to be given to the use of water for dust suppression– use of binding agents like molasses should be considered for unsealed roads and for dust suppression.
- Creating buffer strips of vegetation around land clearance areas to slow down runoff upstream and downstream.
- **Avoid**
  - As far as practicable, avoid disturbance of areas with high erosion potential.
  - Minimise erosion by designing and constructing access roads along gentle slopes and with drainage channels along the roads spaced at intervals dictated by the slope, rainfall pattern and erodibility.
- **Reduce**
  - Implement soil erosion minimisation techniques such as:

– Scheduling construction and maintenance to avoid heavy rainfall periods (i.e., during the dry season) to the extent practical;

– Mulching to stabilize exposed areas;

– Re-vegetating disturbed areas promptly;

– Designing channels for post-construction flows;

  - By applying appropriate design of diversion drains around waste rock dump, road drainage to minimise erosion.

- By doing annual inspections of drainage channels, and maintenance as necessary.
- Soil erosion/sediment delivery needs to be minimized on areas stripped of vegetative cover prior to mining activities, during mining operations and on the post-mining landscape.

- **Restore**

Rehabilitation to consider erosion factors and apply soil erosion control measures described above.

- **Compensate**

None

- **Enhance**

None

- **Monitoring Mechanism**
  - Environmental auditing to verify contractor compliance and soils handling and rehab procedures being implemented.
  - Annual maintenance inspections of drainage channels.
  - Develop and distribute a map of restricted areas (including sensitive soil areas) and demarcate areas for construction activities and infrastructure developments

8.3.6 Recommendations for Soil Stripping and Handling

In order to reduce the overall impact on soil as a resource during the LoM, practical soil stripping and handling procedures and implementation thereof is required. A soil stripping guide requires the following (adapted from MinCoSA, 2019):

- A detailed soil distribution map and associated detailed map legend
- Demarcation of utilizable soil material (horizon depths to be stripped)
- Proposed location for stripped soil horizons to be placed if direct placement is not possible
- Soil material balance reflecting volumes to be moved based on various times throughout the life of mine.

Using the detailed soil map (Figure 3), proposed infrastructure map (Figure 1) and the proposed life of mine the soil stripping guide map was generated and shown in Figure 7. It is recommended that the A-horizon and B-horizons of the soil type be stripped and stockpiled separately. Based on the estimated available soil volumes, ~30% of the stockpile footprint will need to be allocated to the A-horizon soil, with the remaining ~70% left for stockpiling of the B-horizon soils. The recommended stockpile height of 2-3m (not exceeding 3m) was used to estimate when the allocated stockpile footprint and airspace capacity has been reached, i.e. when live placement of soil will be required. It was estimated that the stockpile area will reach capacity after year 6 for 3m high stockpiles and for 2m high stockpiles capacity is reached in the middle of year 5 for the A-horizon stockpile and at the end of year 5 for the B-horizon stockpile (Figure 6).

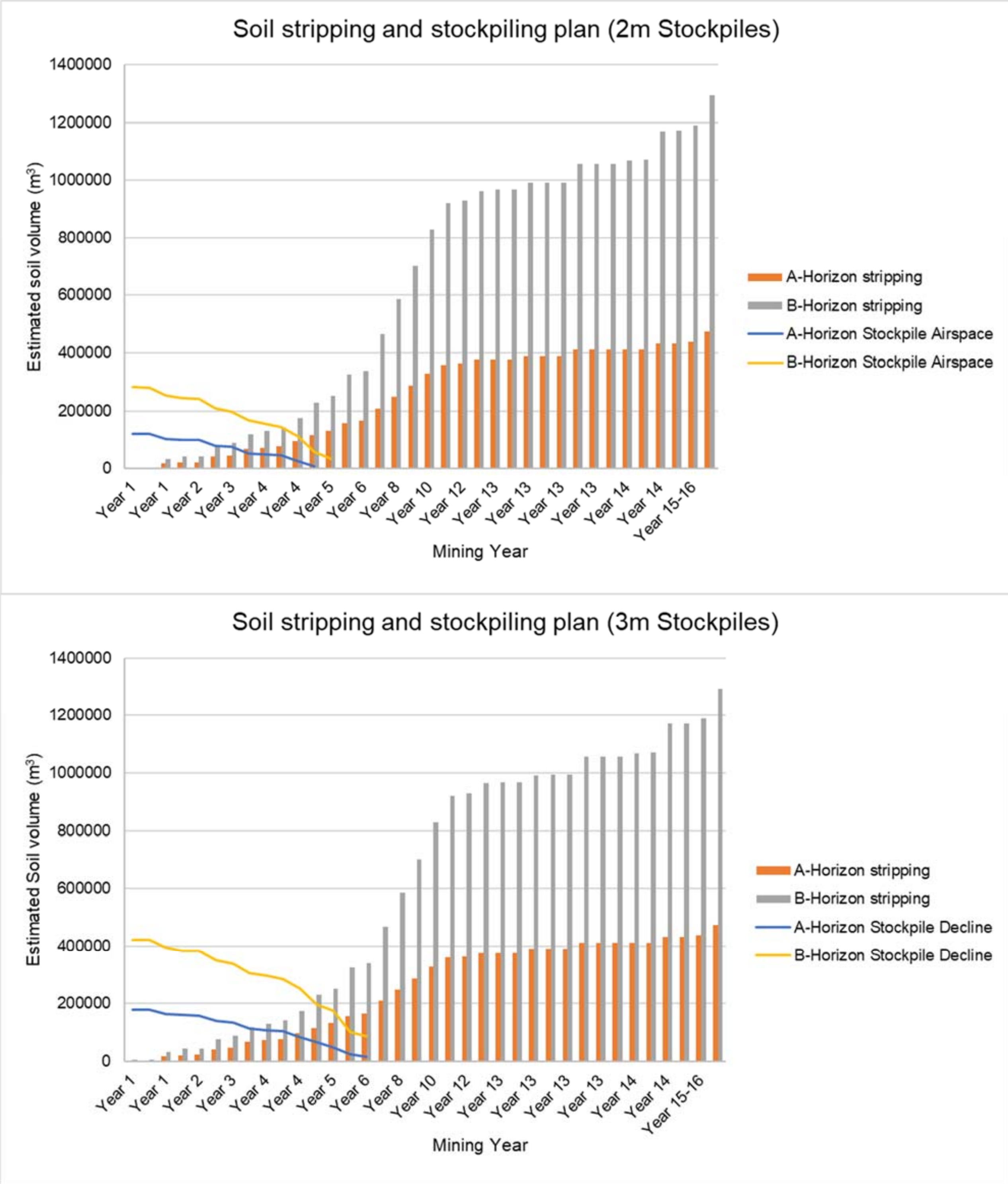
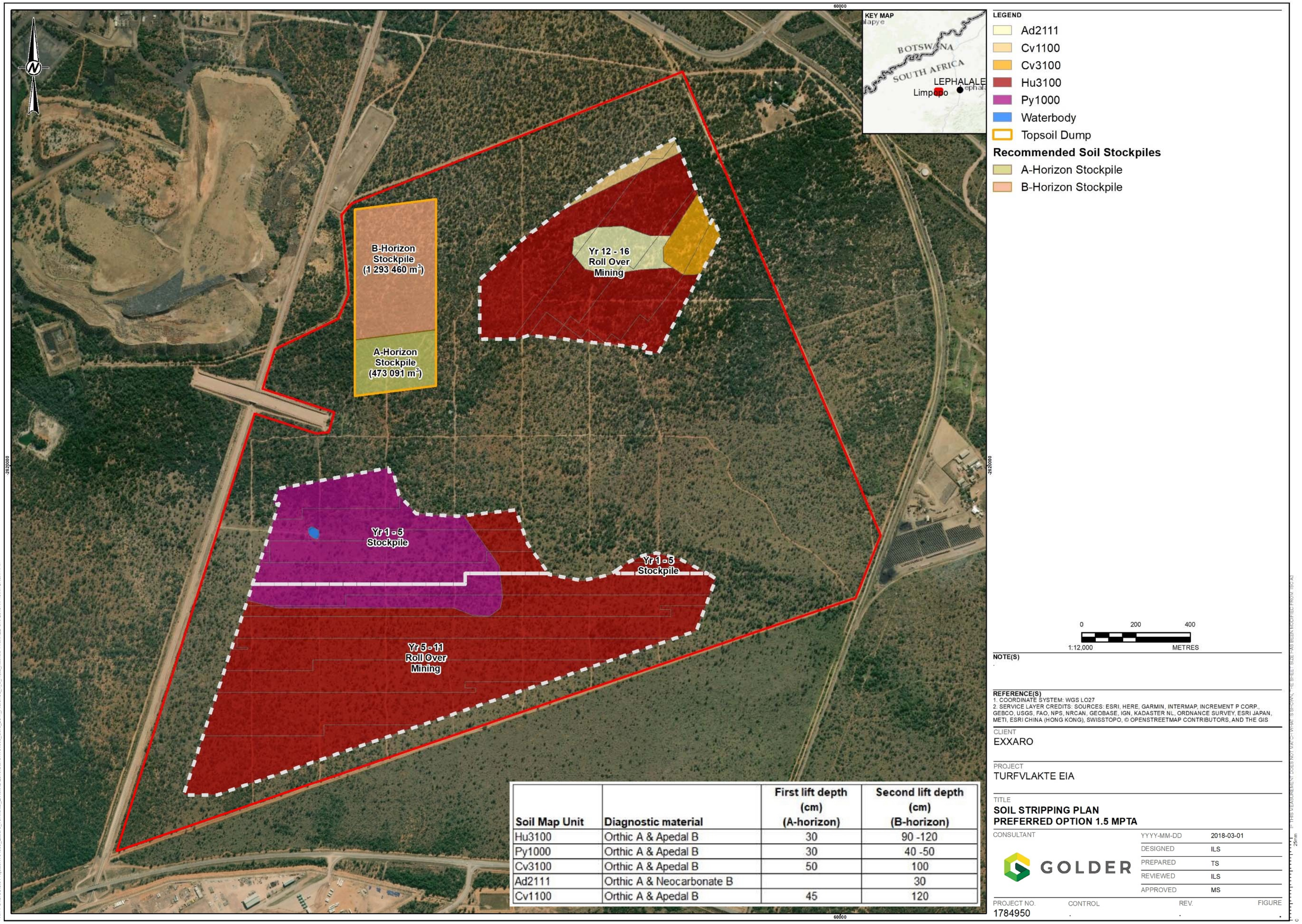


Figure 6: A-horizon and B-horizon stripping according to Mining year and decline of stockpile capacity (excluding bulking) based on 2m and 3m high stockpiles placed at angle of repose.



Soil Map Unit	Diagnostic material	First lift depth (cm) (A-horizon)	Second lift depth (cm) (B-horizon)
Hu3100	Orthic A & Apedal B	30	90 -120
Py1000	Orthic A & Apedal B	30	40 -50
Cv3100	Orthic A & Apedal B	50	100
Ad2111	Orthic A & Neocarbonate B		30
Cv1100	Orthic A & Apedal B	45	120

Figure 7: Soil stripping guide map

8.4 Mechanisms for monitoring compliance

The mechanisms for compliance monitoring with and performance assessment against the environmental management programme and reporting thereof, include:

- Monitoring of impact Management Actions;
- Monitoring and reporting frequency;
- Responsible persons;
- Time period for implementing impact management actions;
- Mechanisms for monitoring compliance;

The impact of the development of Route F activities on soil, land use and land capability can be monitored by the following methods (Table 21).

Table 21: Soil, Land use and Land Capability Monitoring Program

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
Soil quality	Maintain the soil quality along areas which will be developed for mining as well as areas adjacent to mine waste storage facilities.	Collection of at least one sample per hectare for developed areas or where visible signs of contamination is noted (spillage or seepage areas/zones)	All areas which will be developed for mining	■ pH and salinity; ■ Major anions and cations; ■ Sulphate, phosphate, Nitrate, total dissolved solids, electrical conductivity; ■ Heavy metals and hydrocarbons	Annually	Environmental Department
Soil stockpiles	Maintain and minimise the quality and degradation of soil stockpiles	Collection of at least one composite sample per stockpile	Soil stockpiles	■ pH and Salinity; ■ Major anions and cations; ■ Organic matter content for the topsoil; ■ Content of major plant nutrients (CEC); ■ Major cations and anions; ■ Metal and hydrocarbons; ■ Stockpile height (<3 m).	Annually	Environmental Department
Soil erosion	Mitigate and minimise soil erosion	Infrastructure and surface water bodies on-site to be maintained in accordance with the surface water management plan	Soil stockpiles Developed areas Haul roads	■ Assess soil stockpile heights and conditions (i.e. gullies and rills); ■ Assess the condition and effectiveness of vegetation on the stockpiles;	Annually, after rainy season	Environmental Department

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
				■ Assess any evidence of erosion (as per the Surface water management plan); ■ Assess the effectiveness of water versus other dust suppression substances (e.g. molasses or bitumen)		
Land Use	Maintain and minimise land use change within the license area	Evaluation of land use within the mining precinct using satellite imagery	Mining license area	Collection of satellite imagery	Every two years	Environmental Department
Rehabilitated Areas	Maintain the quality and condition of rehabilitated areas	Continuous monitoring of rehabilitated areas for closure compliance	Disturbed areas	■ Organic content of topsoil; ■ Content of major plant nutrients; ■ Contamination assessment (pH, metals, hydrocarbons, electrical conductivity, total dissolved solids, nitrates, sulphate and phosphates); ■ Volume of soil replaced;	Annually	Environmental Department

9.0 DATA GAPS AND ASSESSMENT SHORTCOMINGS

The following limitations are relevant to this report:

- Relevant information relating to the project such as general site arrangement drawings, topographical survey data was made available to Golder by Exxaro and was used in the planning of the field survey and overall assessment of impacts;
- The methodologies and procedures applied in this study are generally followed in the pedology and broader soil science community;
- The presented findings in this report is based on our current understanding of the project and the level of information available at the time of the assessment and can be adjusted if additional information becomes available.
- The detailed civil engineering procedures/standards for final landform was not available at the time of preparation of this report. All soil volume estimations are based on current site layout provided to Golder.
- The mining method for the Turfvlakte Pits is assumed to be as currently used for the Grootegeluk Pit

10.0 CONCLUSIONS

The objectives of the study were as follows:

- To conduct a detailed soil assessment of the proposed Turfvlakte mine infrastructure and classify the observed soils in accordance to the South African Taxonomic Soil Classification System (Section 6.2); derive respective land capability classes of soils underlying the proposed Turfvlakte mine infrastructure and the agricultural potential thereof (Section 6.4.1);
- Map the current land use on the Turfvlakte project area in accordance the Spatial Planning and Land Use Management Act (Act No.16 of 2013) (Section6.5); and
- Identify key potential environmental impacts that will be associated with developments of the proposed mining project (Section 7.0).

Summary of findings:

- The Hutton soil form within the Turfvlakte project area represents ~21.85%, Plooysburg soil form represents ~8.29%, Clovelly represents ~12.15%, Addo represents ~0.98%, dry pans represents ~0.44% including a man-made dam (waterbody) representing approximately 0.021% of the total project area. Majority of the area mapped within the Grootegeluk mine comprises of disturbed area representing ~46.53% and partially disturbed area underlain by Hutton soil form representing ~5.07%. A small coverage of the study area within the Grootegeluk mine comprises of Hutton and plooysburg soil forms which represent ~2.01% and 2.33% respectively.
- The Hu3100 soil form generally comprises of dark reddish brown sandy loam topsoil on reddish yellow loamy sand and is slightly acidic with high cation status. The Plooysburg soil form (Py) comprises of generally dark grey to brown sandy loam topsoil on generally brown gravelly sand with calcrete nodules. The Py1000 soil form is generally slightly acidic to alkaline with a high cation exchange capability.
- The land capability classes that were identified for the Turfvlakte project area fall within class V with a medium agricultural potential. The majority of Turfvlakte project area is currently used for game farming, with the remainder of the land used for commercial purposes (Manketi Lodge), transportation (cross over bridge to Grootegeluk mine) and mining purposes (Grootegeluk mine).

- The key soil and land use aspects affected due to the project activities are soil quality degradation, loss of soil as a resource, land use change, soil contamination, soil compaction and soil erosion. These impacts have high impact significance and when mitigated have low to moderate impact significance.
- An extensive soil quality monitoring programme as per the environmental monitoring programme should be implemented to minimise and/or eliminate the identified impacts.
- The residual impacts include soil degradation due to vegetation clearance and soil disturbances (initial stripping, and soil placement during rehabilitation phase); and insufficient soil available for surface rehabilitation at closure.

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Signature Page

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APPENDIX A

Field Survey Plan

TECHNICAL MEMORANDUM

Draft

DATE 30 November 2017 **PROJECT No.** 1784950

TO Filomaine Swanepoel
Exxaro Resources Limited

CC Marie Schlechter, Elize Herselman, David Love, Aviwe Mgoqi, Katlego Maake

FROM Ilse Snyman **EMAIL** ilsnyman@golder.com

TURFVLAKTE FIELDWORK PLAN – SOIL AND LAND USE SURVEY

1.0 PROJECT UNDERSTANDING

Golder has been appointed by Exxaro's Grootegeluk Mine to conduct the required EIA for the proposed mining activities on the neighbouring farm, Turfvlakte 463 LQ, Limpopo province, South Africa.

The proposed project footprint area of the development covers an area of approximately ~630ha.

This technical memorandum details the approach for the required fieldwork for the soil, land capability and land use assessment as part of the above mentioned EIA project.

2.0 OBJECTIVES

The objective of the survey is to obtain sufficient baseline information on the soil characteristics, land capability and land use in the proposed development and infrastructural areas in order to:

- Understand the baseline soil conditions;
- Provide a detailed description of the baseline and pre-development soil characteristics, existing land capability and existing land use; and
- Describe and evaluate any other limiting characteristics of the soils.

3.0 APPROACH

3.1 Preparation of Field map

In preparation for the field survey, a desktop study was conducted which included the review of the historic and recent aerial imagery, previous soil reports, evaluating topographic, land cover, land use, land type maps and memoirs, and geological maps of the study area.

Portions of the proposed infrastructure (north-east of the pit), particularly the haul roads, conveyor routes, certain stockpile areas, and the new plant area appear to be within existing disturbed areas. These areas will however by evaluated with a reconnaissance survey, to confirm the extent of disturbance, and may potentially be mapped as anthrosol soils (any soils that have been *modified profoundly* by human activities, including burial, partial removal, cutting and filling, waste disposal, manuring, and irrigated agriculture). The reviewed background information was used to plan and design the field survey and identify the preliminary soil observation locations.

3.2 Field survey

A semi-detailed reconnaissance (at 1:20 000) ***field survey*** will be conducted to delineate (into map units) and document the land use, natural resources climate, terrain form and soil type of the project area. Where the topography is undulating, the soils will be mapped along transects from hilltops to the valley bottom positions. The locations of the transect walks will be set out during the desktop assessment of the aerial imagery for the site. In areas which are flat, the soil observations will be conducted according to a grid system. The soil variability will be assessed by augering to a depth of 120 cm or deeper, unless prevented by impenetrable material or excessive wetness. Observable soil characteristics such as colour, texture, soil depth, stoniness, and drainage class and parent material will be logged. At each observation point the relevant and distinct features will also be recorded such as signs of erosion, vegetation cover, micro-topography, aspect and fauna. Once the dominant soil types have been identified during the transect walks, representative sites (modal profiles) will be located, described in detail and sampled. The soil characteristics will be described and classified according to the Taxonomic Soil Classification System for South Africa (Soil Classification Working Group, 1991). For each modal profile the following features will be recorded in field:

- Soil form and family (as defined in the Taxonomic Soil Classification System for South Africa,1991);
- Soil depth (effective depth);
- Estimated soil texture;
- Soil structure, coarse fragments, calcareousness;
- Underlying material;
- Current land use; and
- Land capability.

The proposed observation points for the transect walks are shown in Figure 1 The co-ordinates of the proposed observation points for the transect walks are listed in Table 1.

Table 1: Proposed observation points for transect walks

OP	lat	lon	OP	lat	lon
1	-23.6884	27.58649	19	-23.6685	27.58256
2	-23.6787	27.57806	20	-23.6785	27.57388
3	-23.6844	27.57523	21	-23.6669	27.5854
4	-23.6757	27.57094	22	-23.6785	27.58682
5	-23.6765	27.58394	23	-23.6868	27.57991
6	-23.6755	27.57536	24	-23.6782	27.57021
7	-23.6725	27.57079	25	-23.6833	27.57896
8	-23.6765	27.58976	26	-23.6832	27.58729
9	-23.6909	27.56736	27	-23.6882	27.57019
10	-23.6702	27.5884	28	-23.6881	27.58081
11	-23.6731	27.57912	29	-23.6913	27.57393
12	-23.6728	27.58713	30	-23.6868	27.57991
13	-23.6785	27.58139	31	-23.6782	27.57021
14	-23.6701	27.58159	32	-23.6833	27.57896
15	-23.6686	27.57998	33	-23.6832	27.58729
16	-23.6705	27.57651	34	-23.6882	27.57019
17	-23.6685	27.58534			
18	-23.6733	27.58256			

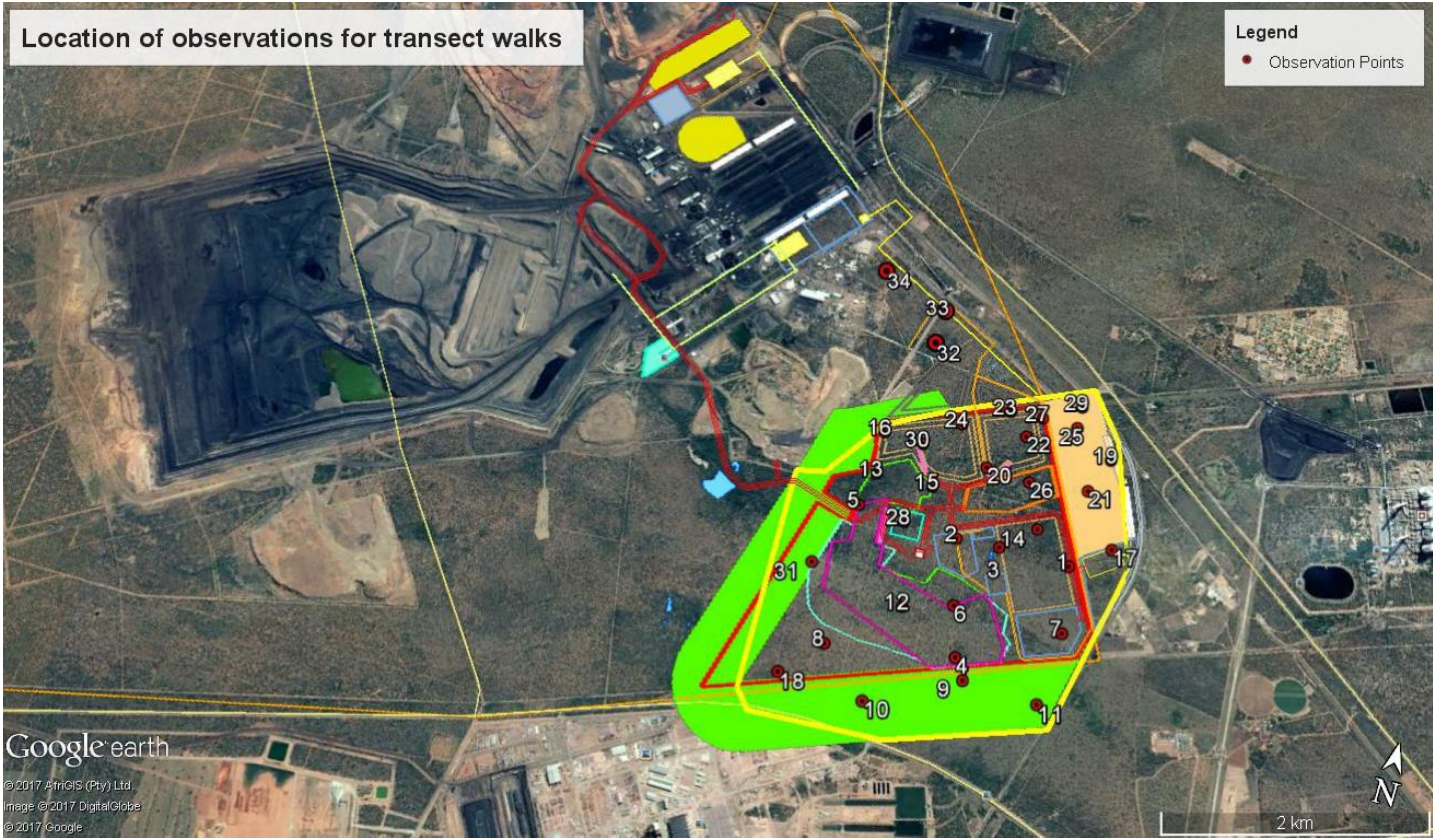

Figure 1: Proposed observation points for transect walks

3.3 Laboratory Analysis

Laboratory analysis of the soil samples will be conducted at Eco-Analytical Laboratories at the University of the North West, South Africa. The topsoil properties which will be analysed, as required for classification purposes include:

- Phosphorus (Bray 1);
- Exchangeable cations – Na, K. Ca, Mg (Ammonium Acetate Extraction);
- pH (water);
- Organic matter content (topsoils only);
- Clay content; and
- Acid saturation (%).

The subsoil samples will be analysed for Exchangeable cations – Na, K. Ca, Mg (Ammonium Acetate Extraction);

4.0 LOGISTICAL SURVEY AND SAMPLING REQUIREMENTS

In order to conduct the field survey indicated the following logistics and support is required to ensure a successful field survey and sampling campaign:

- Confirmation of the suitability of the dates for the site visit (4 – 8 December 2017); and
- One Exxaro environmental team personnel or geologist familiar with the prospecting rights area to support and assist with fieldwork for the duration of the field survey, with their own vehicle.
- Permit to remove collected soil samples from site.

5.0 WORK SCHEDULE

The proposed work schedule for the duration of the sampling campaign is described in Table 2.

Table 2: Field Survey and sampling schedule

Date	Location	Activity	Required support
Day 1 4/12/2017	■ Mine office ■ Site	■ Arrival on site ■ Exxaro representative meeting with Golder team ■ Induction ■ Field reconnaissance survey	■ Site access

Date	Location	Activity	Required support
Day 2 - 5 5 – 8 /12/2017	■ Turvfvlakte	■ Field survey ■ Soil sampling	■ Site access
Afternoon Day 5 8/12/2017	■ Mine office	■ Depart for Johannesburg from Lephalale	Soil sample permit to remove samples from site

6.0 GOLDER TASK TEAM

The team for the survey and sampling campaign is indicated in **Table 3** below.

Table 3: Task team

Team member	Duration onsite
Katlego Maake	Monday 4 December – Friday 8 December 2017;
Aviwe Mgopi	

7.0 ASSUMPTIONS

The following assumptions are relevant:

- A dedicated person will be available to accompany Golder personnel during the fieldwork/site activities and to assist to gain access to required areas;
- All soil sampling will be done by means of a hand-auger;
- The proposed scope of work is based on our current understanding of the level of information available and can be adjusted if additional information becomes available.
- The security of buried services situated anywhere on the project site(s), which are NOT identified on the drawings provided or suitably demarcated on site to us, will remain the responsibility of the client;
- The investigation procedures offered herein will involve operations and techniques using standard health and safety norms applied by Golder to all its projects, and generally followed in the geotechnical investigation industry. In the event that specific client requirements for safety issues are to be applied, of which we have not been appraised in prior documentation, these will be implemented to the extent reasonable and possible (within investigation industry standards and norms), but may attract additional time and cost which are not covered in this present proposal and will be negotiated as contract extras;
- Any water logged (or soft underfoot) areas may also present constraints insofar as accessibility of the site for investigatory equipment is concerned, and may therefore also require reconsideration of the proposed programme and test method (and where necessary costing).

8.0 CONCLUDING REMARKS

It is envisioned that the sampling will require five day's field work, to be conducted on 4-8 December 2017. Samples will be couriered to the North West University Analytical Laboratory in South Africa for the other analysis by 12 December 2017. Laboratory analysis results may be expected after about 3-4 weeks.

9.0 REFERENCES

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Ilse Snyman
Soil Scientist

Marie Schlechter
Project Manager

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APPENDIX B

Representative Soil Profiles

Geographic Coordinates of Soil Sampling Locations

A total of fourteen (**14**) soil samples were selected for analysis from an initial thirty (**30**) soil sampling and observation points presented in the sampling plan. Ten (**10**) soil samples were also collected from the Grootegeluk mine along the footprint of the proposed infrastructure. The geographic location of the selected soil samples is presented in Table B1. In addition to the initially proposed sampling points, two additional locations were sampled (31 and S35).

Table B1: Geographic coordinates of soil sampling and observation points

Position ID	Latitude	Longitude	Study Area
3	-23.678481°	27.581390°	Turfvlakte Project Site
6	-23.683319°	27.578959°	
7	-23.683214°	27.587285°	
9	-23.688142°	27.580810°	
13	-23.675669°	27.570938°	
14	-23.676505°	27.583938°	
15	-23.675511°	27.575356°	
18	-23.690933°	27.567364°	
19	-23.670198°	27.588399°	
23	-23.668627°	27.579982°	
24	-23.670484°	27.576510°	
28	-23.678490°	27.573883°	
31	-23.682994°	27.567801°	
S35	-23.681029°	27.589356°	
C11N	-23.658920°	27.558680°	Grootegeluk Mine
C28	-23.642280°	27.548970°	
C32	-23.649710°	27.558220°	
OB1	-23.652260°	27.551750°	
OB1A	-23.652260°	27.551750°	
OB2	-23.652050°	27.547460°	
OB3	-23.660290°	27.559670°	
OB4	-23.656400°	27.565120°	
OB6	-23.678800°	27.558700°	
OB7	-23.677020°	27.563090°	
OB8	-23.677020°	27.563090°	

Table B2: Photograph log of representation soil modal profiles

AK1000 **SaLm**	
Askham **(Ak1000)**	
Ar1100 **Cl**	
Arcadia **(Ar1100)**	
Cv3100 **LmSa**	
Clovelly **(Cv3100)**	
Fernwood **Fw2210** **Sa**	
Fernwood **(FW2210)**	

Gr1000 LmSa	
Garies (Gr1000)	
Hu3100 SaLm	
Hutton (Hu3100) (Hu3200)	
Ky1100 SaLm	
Kimberly (Ky1100)	
Mp1100 LmSa	
Molopo (Mp1100)	

Py1000 **SaLm**	
Plooysburg **(Py1000)**	

Wa2000 **Sa**	
Wasbank **(Wa2000)**	

APPENDIX C

Laboratory Certificates

NORTH-WEST UNIVERSITY
ECO-ANALYTICA

Eco Analytica
P.O. Box 19140
NOORDBRUG 2522
Tel: (018) 293 3900

GOLDER (TURFVLAKTE / LEPHALALE)

2/2/2018

Nutrient Status

Sample no.	Ca	Mg	K	Na	P	$pH(H_2O)$	Walkley Black (%C	EC (mS/m)
	(mg/kg)							
3-1	320.5	41.5	55.0	0.5	5.2	5.05	0.37	21
3-2	533.0	77.0	22.0	1.5	3.7	5.44		12
3-3	1349.0	88.5	4.0	1.0	3.7	6.44		40
6-1	854.5	103.0	167.5	1.0	5.5	5.90	0.91	35
6-2	1104.0	170.5	92.5	1.5	3.6	6.39		30
6-3	1288.5	199.0	123.5	1.0	3.5	6.81		22
7-1	899.0	99.5	152.5	0.5	5.0	6.57	0.52	24
7-2	1015.0	138.5	125.5	0.5	3.9	7.01		23
7-3	893.0	166.0	113.5	1.0	3.6	6.95		41
7-4	1071.5	176.5	191.0	1.5	3.6	7.21		55
9-1	265.5	81.0	103.5	0.5	4.0	5.72	0.31	12
9-2	598.5	172.0	126.0	0.5	3.7	6.08		8
13-1	458.5	73.0	73.5	0.5	4.0	5.85		33
13-2	330.0	85.0	88.5	0.5	3.7	5.91		11
13-3	543.5	163.5	99.0	1.0	3.7	6.35		13
14-1	278.5	59.0	37.0	1.0	14.8	4.97	0.35	20
14-2	1145.0	219.0	60.5	2.0	4.2	6.24		25
14-3	1550.0	258.5	46.5	5.5	4.0	6.70		36
15-1	287.0	43.5	68.5	1.0	3.9	5.75		16
15-2	356.5	84.0	54.0	1.0	3.8	5.74		14
18-1	203.0	45.0	79.5	1.0	4.2	5.27		15
18-2	322.0	116.5	91.5	1.0	3.8	5.29		21
19-1	1155.0	226.5	159.0	8.5	6.1	6.57	0.60	47
19-2	1734.5	314.5	70.5	26.5	4.5	7.82		63
19-3	2856.5	600.5	74.0	52.5	4.0	8.38		71
19-4	2833.0	681.0	49.5	85.5	3.4	8.39		77
23-1	78.0	16.5	2.0	1.0	4.8	5.38		14
23-2	11.0	6.5	1.5	1.0	4.1	4.82		11
24-1	12.0	2.0	1.5	1.0	7.6	4.75		9
24-2	7.0	2.0	1.0	1.0	3.8	4.73		6
28-1	2094.0	152.5	166.5	1.5	6.1	7.11		56
28-2	2521.5	153.0	189.0	2.0	4.3	7.98		61
29-1	2653.0	740.0	127.0	1.0	4.3	8.25		46
29-2	637.0	149.5	1.5	1.0	4.2	8.54		19
29-3	358.5	133.0	28.5	1.0	4.1	8.39		13
31-1	1467.0	173.5	225.0	1.5	3.9	7.24		46
31-2	2778.5	198.0	93.0	1.5	3.4	7.58		51
S35-1	2509.5	476.5	531.0	2.0	7.5	6.13	1.94	66
S35-2	2543.5	549.0	230.5	12.0	4.1	6.43	0.60	23
C11N-1	958.0	157.0	119.0	1.5	5.3	6.98	2.45	47
C11N-2	765.0	188.5	32.0	1.5	4.0	6.85		28
C28-2	77.0	6.5	1.0	1.0	5.9	4.54		27
C28-3	77.0	5.0	1.0	1.0	4.0	5.02		15
C32-2	591.0	113.0	1.5	1.5	3.7	5.24		145
C32-3	2699.0	1150.5	2.0	29.5	3.6	6.20		154
OB1-1	1391.0	339.0	161.5	2.0	6.1	6.47	0.74	62
OB1-2	1445.0	261.5	15.0	9.5	4.2	6.93		42
OB1-3	625.0	99.5	2.0	2.0	4.1	6.12		46
OB1A-1	1188.5	231.5	44.5	2.0	6.0	5.80	1.67	43
OB1A-2	622.0	126.5	2.0	2.0	4.3	5.66		24
OB2-2	1058.5	138.5	2.0	2.0	4.7	4.71		243
OB2-3	182.5	75.5	2.0	1.0	3.9	5.75		91
OB3-1	1212.5	171.5	107.5	1.0	5.3	6.74	1.96	51
OB3-2	377.0	105.0	59.0	1.0	3.8	6.72		35
OB3-3	264.0	88.5	84.5	1.0	3.7	6.14		28
OB3-4	193.5	90.5	35.0	1.5	3.6	5.79		14
OB4-1	786.5	231.5	126.5	2.0	3.8	5.72	0.58	55
OB4-2	1388.5	238.0	177.5	2.0	5.9	7.09		49
OB4-3	1264.5	452.5	32.5	4.5	3.6	6.29		52
OB6-1	2708.0	244.0	537.0	1.5	4.4	7.79	1.73	51
OB6-2	2399.0	272.5	293.0	2.0	4.1	7.90		41
OB6-3	2356.0	227.5	209.0	1.5	3.9	8.04		36
OB7N-1	1387.5	168.5	148.0	2.0	7.2	7.49	1.07	44
OB7N-2	1125.5	208.5	206.5	2.0	4.0	6.92		30
OB7N-3	1544.0	271.0	194.0	2.0	3.9	7.41		93
OB8-1	1891.0	211.0	225.0	11.5	4.2	7.59	0.78	48
OB8-2	1653.5	229.5	217.0	33.0	3.7	7.39		110

Exchangeable cations

Sample no.	Ca	Mg	K	Na	CEC	S-value	Base saturation (%)	pH(H_2O)	pH(KCl)
	(cmol(+)/kg)								
3-1	1.60	0.34	0.14	0.00	18.93	2.08	11.01	5.05	
3-2	2.66	0.63	0.06	0.01	21.85	3.36	15.36	5.44	
3-3	6.73	0.73	0.01	0.00	14.78	7.47	50.56	6.44	
6-1	4.26	0.85	0.43	0.00	22.25	5.55	24.92	5.90	
6-2	5.51	1.40	0.24	0.01	14.12	7.16	50.67	6.39	
6-3	6.43	1.64	0.32	0.00	16.56	8.39	50.67	6.81	
7-1	4.49	0.82	0.39	0.00	17.79	5.70	32.03	6.57	
7-2	5.06	1.14	0.32	0.00	12.79	6.53	51.04	7.01	
7-3	4.46	1.37	0.29	0.00	15.77	6.12	38.78	6.95	
7-4	5.35	1.45	0.49	0.01	23.22	7.30	31.42	7.21	
9-1	1.32	0.67	0.27	0.00	17.60	2.26	12.84	5.72	
9-2	2.99	1.42	0.32	0.00	14.30	4.73	33.05	6.08	
13-1	2.29	0.60	0.19	0.00	20.16	3.08	15.28	5.85	
13-2	1.65	0.70	0.23	0.00	18.01	2.58	14.30	5.91	
13-3	2.71	1.35	0.25	0.00	13.34	4.32	32.36	6.35	
14-1	1.39	0.49	0.09	0.00	19.71	1.97	10.02	4.97	
14-2	5.71	1.80	0.16	0.01	15.05	7.68	51.02	6.24	
14-3	7.73	2.13	0.12	0.02	18.96	10.01	52.78	6.70	
15-1	1.43	0.36	0.18	0.00	15.23	1.97	12.94	5.75	
15-2	1.78	0.69	0.14	0.00	16.63	2.61	15.72	5.74	
18-1	1.01	0.37	0.20	0.00	15.77	1.59	10.10	5.27	
18-2	1.61	0.96	0.23	0.00	16.86	2.80	16.63	5.29	
19-1	5.76	1.86	0.41	0.04	15.73	8.07	51.32	6.57	
19-2	8.66	2.59	0.18	0.12	17.40	11.54	66.32	7.82	
19-3	14.25	4.94	0.19	0.23	23.48	19.61	83.54	8.38	
19-4	14.14	5.60	0.13	0.37	23.64	20.24	85.61	8.39	
23-1	0.39	0.14	0.01	0.00	12.34	0.53	4.33	5.38	
23-2	0.05	0.05	0.00	0.00	11.17	0.12	1.04	4.82	
24-1	0.06	0.02	0.00	0.00	14.96	0.08	0.57	4.75	
24-2	0.03	0.02	0.00	0.00	10.87	0.06	0.54	4.73	
28-1	10.45	1.26	0.43	0.01	15.70	12.14	77.29	7.11	
28-2	12.58	1.26	0.48	0.01	16.75	14.33	85.59	7.98	
29-1	13.24	6.09	0.33	0.00	24.26	19.66	81.03	8.25	
29-2	3.18	1.23	0.00	0.00	10.75	4.42	41.10	8.54	
29-3	1.79	1.09	0.07	0.00	7.70	2.96	38.48	8.39	
31-1	7.32	1.43	0.58	0.01	18.31	9.33	50.96	7.24	
31-2	13.86	1.63	0.24	0.01	25.75	15.74	61.13	7.58	
S35-1	12.52	3.92	1.36	0.01	32.26	17.81	55.22	6.13	
S35-2	12.69	4.52	0.59	0.05	35.14	17.85	50.81	6.43	
C11N-1	4.78	1.29	0.31	0.01	12.32	6.38	51.81	6.98	
C11N-2	3.82	1.55	0.08	0.01	10.75	5.46	50.78	6.85	
C28-2	0.38	0.05	0.00	0.00	12.37	0.44	3.60	4.54	
C28-3	0.38	0.04	0.00	0.00	10.57	0.43	4.09	5.02	
C32-2	2.95	0.93	0.00	0.01	15.36	3.89	25.33	5.24	
C32-3	13.47	9.47	0.01	0.13	42.50	23.07	54.28	6.20	
OB1-1	6.94	2.79	0.41	0.01	18.10	10.15	56.11	6.47	
OB1-2	7.21	2.15	0.04	0.04	14.74	9.44	64.06	6.93	
OB1-3	3.12	0.82	0.01	0.01	14.79	3.95	26.72	6.12	
OB1A-1	5.93	1.91	0.11	0.01	16.38	7.96	48.58	5.80	
OB1A-2	3.10	1.04	0.01	0.01	11.90	4.16	34.96	5.66	
OB2-2	5.28	1.14	0.01	0.01	13.15	6.44	48.95	4.71	
OB2-3	0.91	0.62	0.01	0.00	17.25	1.54	8.94	5.75	
OB3-1	6.05	1.41	0.28	0.00	15.18	7.74	50.99	6.74	
OB3-2	1.88	0.86	0.15	0.00	13.73	2.90	21.13	6.72	
OB3-3	1.32	0.73	0.22	0.00	10.75	2.27	21.09	6.14	
OB3-4	0.97	0.74	0.09	0.01	12.49	1.81	14.47	5.79	
OB4-1	3.92	1.91	0.32	0.01	19.84	6.16	31.06	5.72	
OB4-2	6.93	1.96	0.46	0.01	18.18	9.35	51.43	7.09	
OB4-3	6.31	3.72	0.08	0.02	21.00	10.14	48.27	6.29	
OB6-1	13.51	2.01	1.38	0.01	21.96	16.90	76.99	7.79	
OB6-2	11.97	2.24	0.75	0.01	18.99	14.97	78.85	7.90	
OB6-3	11.76	1.87	0.54	0.01	17.03	14.17	83.19	8.04	
OB7N-1	6.92	1.39	0.38	0.01	14.60	8.70	59.58	7.49	
OB7N-2	5.62	1.72	0.53	0.01	14.79	7.87	53.21	6.92	
OB7N-3	7.70	2.23	0.50	0.01	17.83	10.44	58.57	7.41	
OB8-1	9.44	1.74	0.58	0.05	17.61	11.80	67.01	7.59	
OB8-2	8.25	1.89	0.56	0.14	17.19	10.84	63.05	7.39	

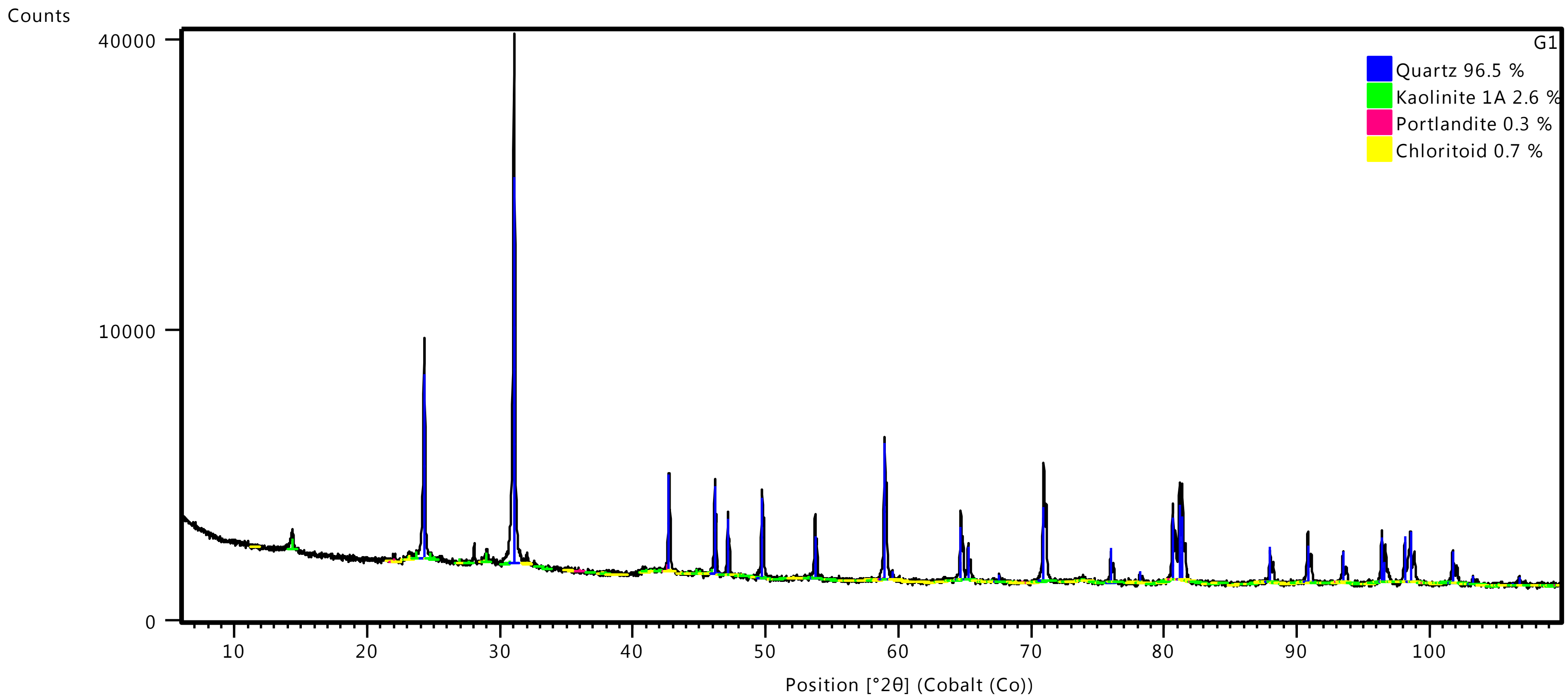
HANDBOOK OF STANDARD SOIL TESTING METHODS FOR ADVISORY PURPOSES
Exchangeable cation 1M NH_4-Asetaat pH=7
CEC: 1 M Na-asetaat pH=7
Extractable, Exchangeable micro-elements: 0.02M $(NH_4)_2$ EDTA.H_2O

EC: Saturated Extraction
pH H_2O/KCl: 1:2.5 Extraction
Phosphorus: P-Bray 1 Extraction

31/1/2018 **Particle Size Distribution**

Sample no.	> 2mm (%)	Sand	Silt	Clay
		(% < 2mm)		
3-1	2.3	88.9	3.0	8.1
3-2	13.9	81.5	0.9	17.6
3-3	40.2	77.1	1.3	21.6
6-1	0.7	88.6	0.8	10.6
6-2	2.8	86.1	0.8	13.1
6-3	1.8	81.4	0.8	17.8
7-1	1.9	88.9	0.8	10.3
7-2	1.8	89.2	2.9	7.9
7-3	2.0	85.7	3.2	11.1
7-4	3.2	86.2	0.8	13.0
9-1	1.3	88.7	6.1	5.2
9-2	0.9	83.7	4.0	12.2
13-1	0.0	91.4	5.7	2.9
13-2	1.0	91.2	5.8	2.9
13-3	0.3	91.1	3.8	5.1
14-1	0.3	86.6	8.2	5.2
14-2	0.5	76.9	13.1	10.0
14-3	0.5	75.7	13.8	10.5
15-1	1.0	88.8	6.0	5.2
15-2	10.8	85.0	6.7	8.2
18-1	1.3	89.4	3.8	6.8
18-2	0.8	86.7	1.7	11.5
19-1	0.3	84.5	6.2	9.3
19-2	0.2	79.7	10.8	9.5
19-3	0.3	76.7	11.2	12.1
19-4	13.4	72.8	13.1	14.2
23-1	0.0	96.0	1.6	2.4
23-2	0.1	94.1	1.6	4.4
24-1	0.0	94.2	1.5	4.3
24-2	0.1	94.1	1.6	4.4
28-1	1.2	86.8	7.9	5.3
28-2	1.5	84.4	8.0	7.6
29-1	19.6	88.9	7.2	3.9
29-2	7.6	95.7	1.2	3.1
29-3	0.1	96.1	1.1	2.8
31-1	0.4	86.3	3.6	10.1
31-2	45.8	84.1	6.3	9.6
S35-1	1.9	52.3	10.6	37.1
S35-2	2.3	55.6	4.3	40.1
C11N-1	20.4	89.3	4.2	6.5
C11N-2	17.1	89.8	1.4	8.8
C28-2	2.1	95.9	1.2	2.9
C28-3	0.1	96.0	1.6	2.4
C32-2	1.1	91.4	1.7	6.9
C32-3	33.5	90.5	5.7	3.8
OB1-1	9.2	83.1	9.2	7.7
OB1-2	13.0	90.2	4.4	5.4
OB1-3	1.2	91.6	3.8	4.6
OB1A-1	14.8	79.4	9.8	10.8
OB1A-2	2.6	89.1	3.9	7.0
OB2-2	3.1	93.5	1.7	4.8
OB2-3	0.6	93.7	1.7	4.7
OB3-1	2.4	83.5	9.9	6.6
OB3-2	1.5	89.6	3.7	6.7
OB3-3	1.3	90.5	2.9	6.6
OB3-4	40.7	88.3	1.2	10.5
OB4-1	1.0	78.1	7.8	14.1
OB4-2	1.2	75.2	12.7	12.1
OB4-3	3.0	71.5	8.3	20.1
OB6-1	18.1	74.5	14.5	11.0
OB6-2	4.1	76.3	8.4	15.3
OB6-3	2.2	79.8	10.4	9.8
OB7N-1	0.3	88.2	7.3	4.5
OB7N-2	0.2	86.0	5.1	8.9
OB7N-3	0.5	83.5	5.2	11.3
OB8-1	0.1	83.7	5.1	11.2
OB8-2	0.7	85.3	5.4	9.3

This laboratory participates in the following quality control schemes:
International Soil-Analytical Exchange (ISE), Wageningen, Nederland.



Counts
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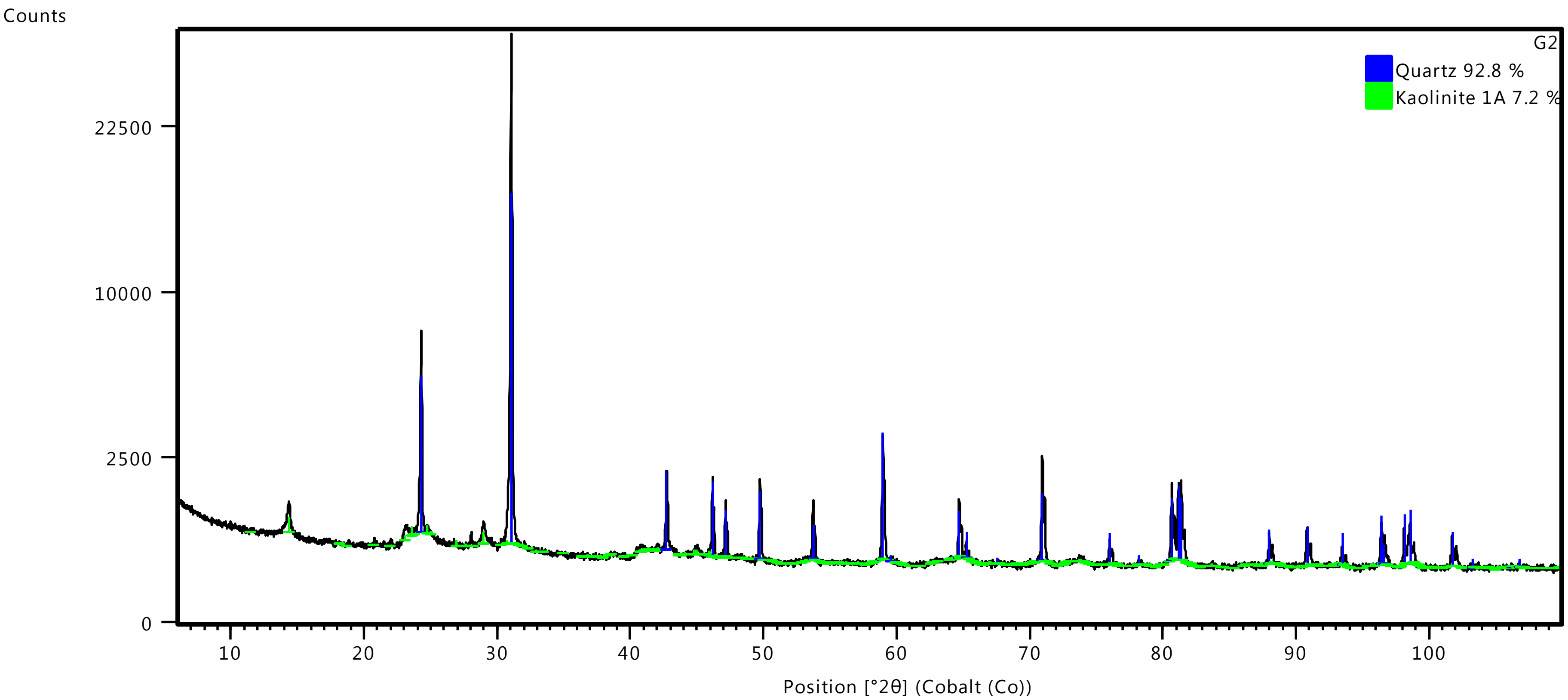
G1
Quartz 96.5 %
Kaolinite 1A 2.6 %
Portlandite 0.3 %
Chloritoid 0.7 %
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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Kaolinite 1A 7.2 %
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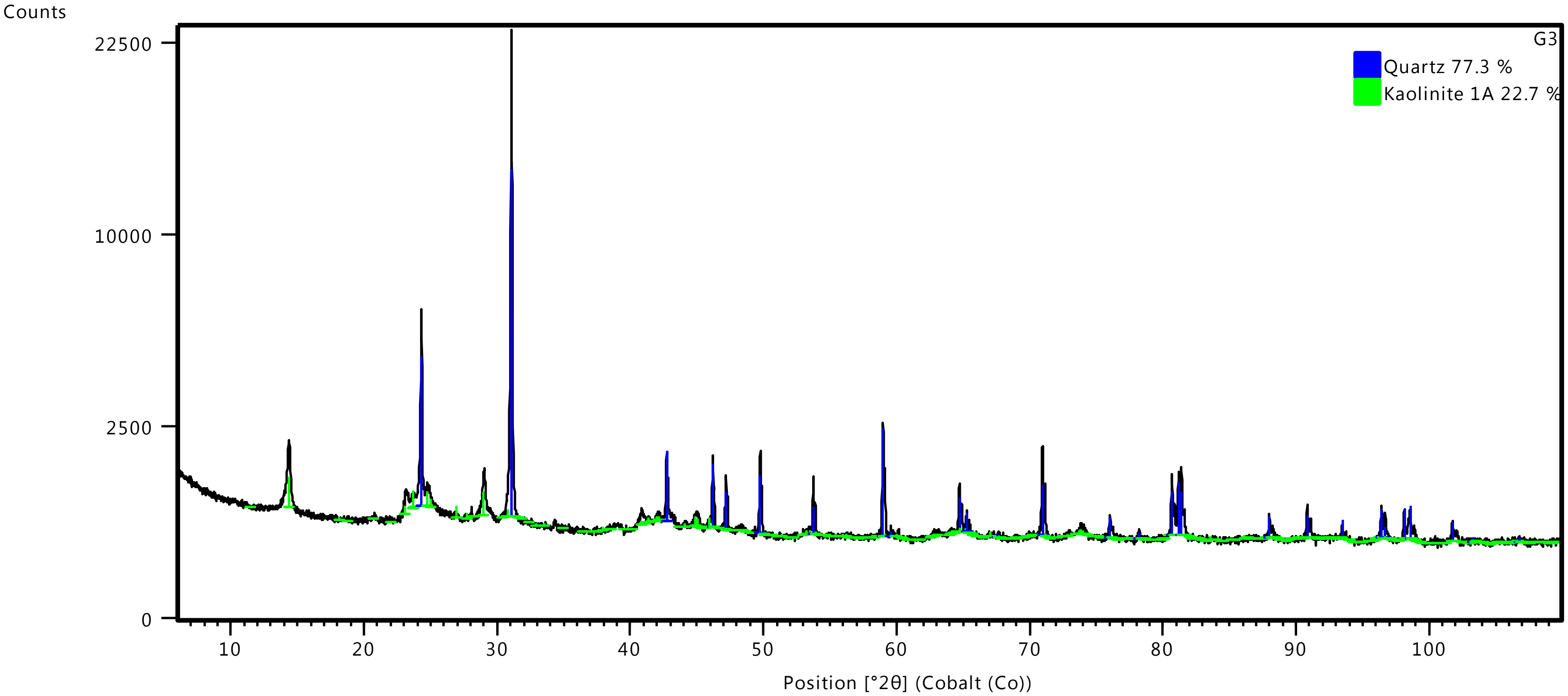
80
90
100
Position [°2θ] (Cobalt (Co))



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2500
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Quartz 77.3 %
Kaolinite 1A 22.7 %
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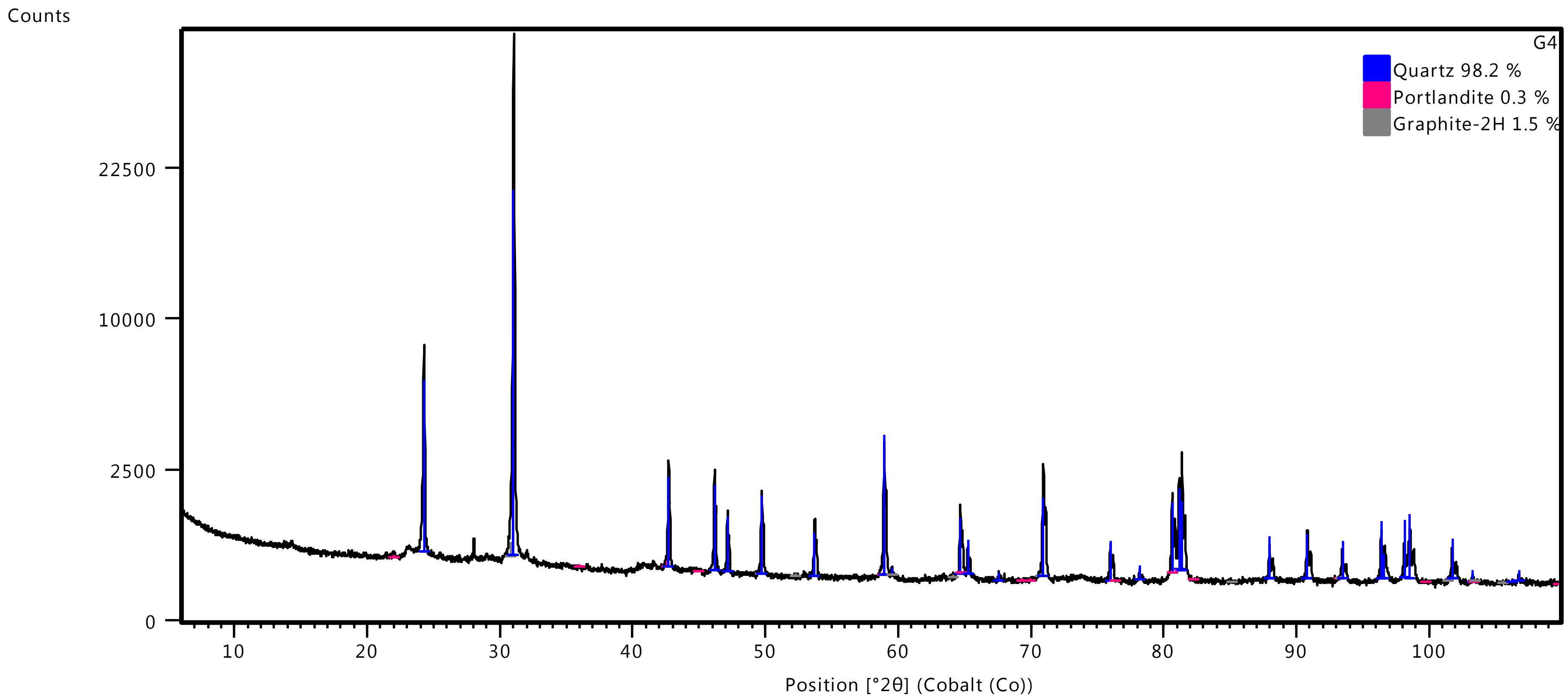
70
80
90
100
Position [°2θ] (Cobalt (Co))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Portlandite 0.3 %
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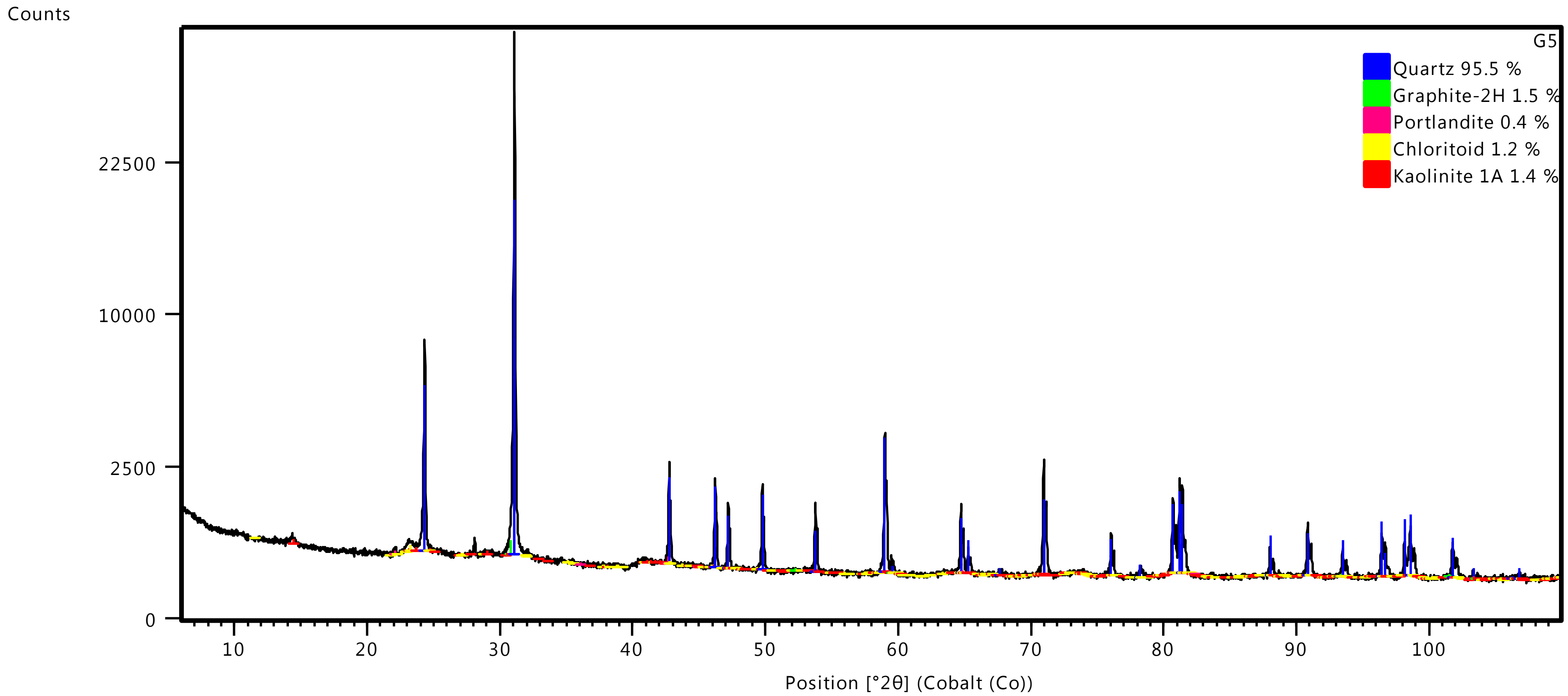
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



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2500
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G5
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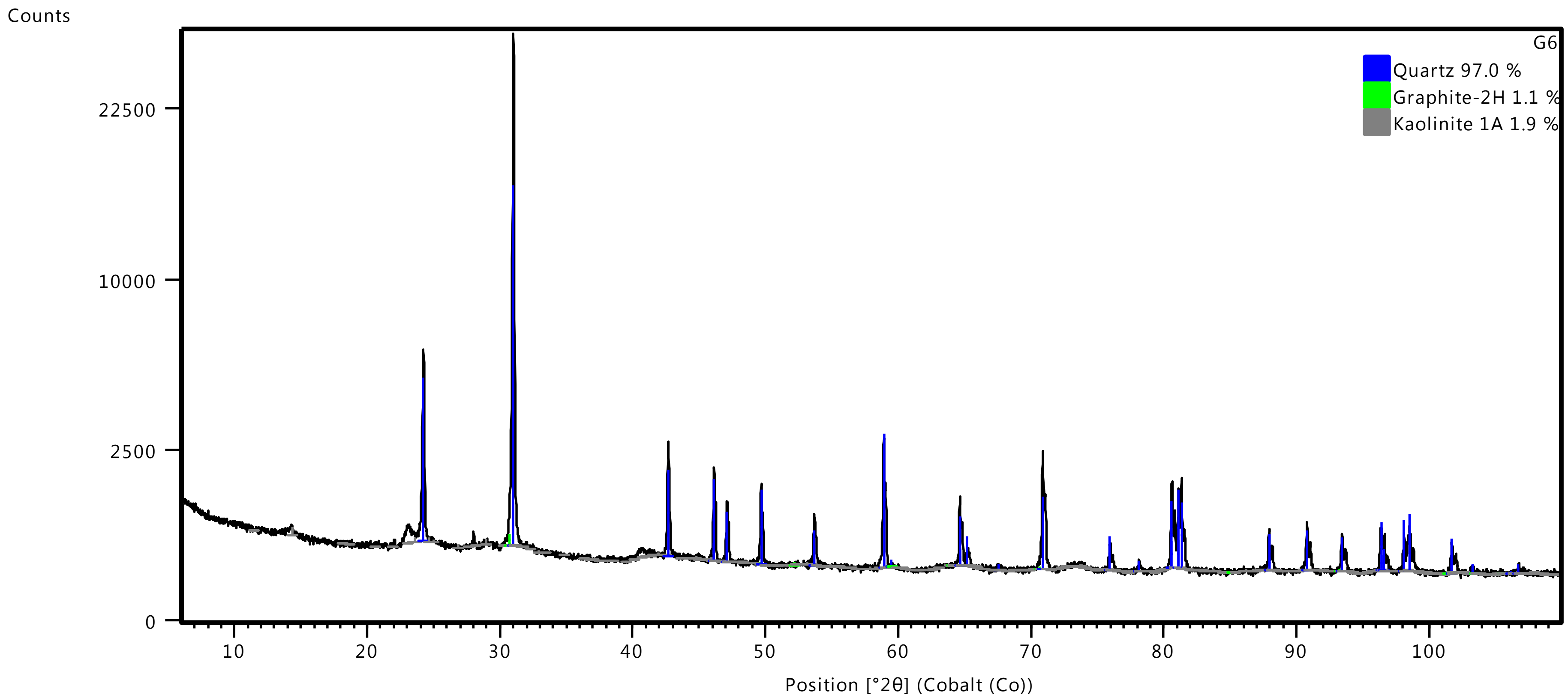
Graphite-2H 1.5 %
Portlandite 0.4 %
Chloritoid 1.2 %
Kaolinite 1A 1.4 %
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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Graphite-2H 1.1 %
Kaolinite 1A 1.9 %
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2500
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40
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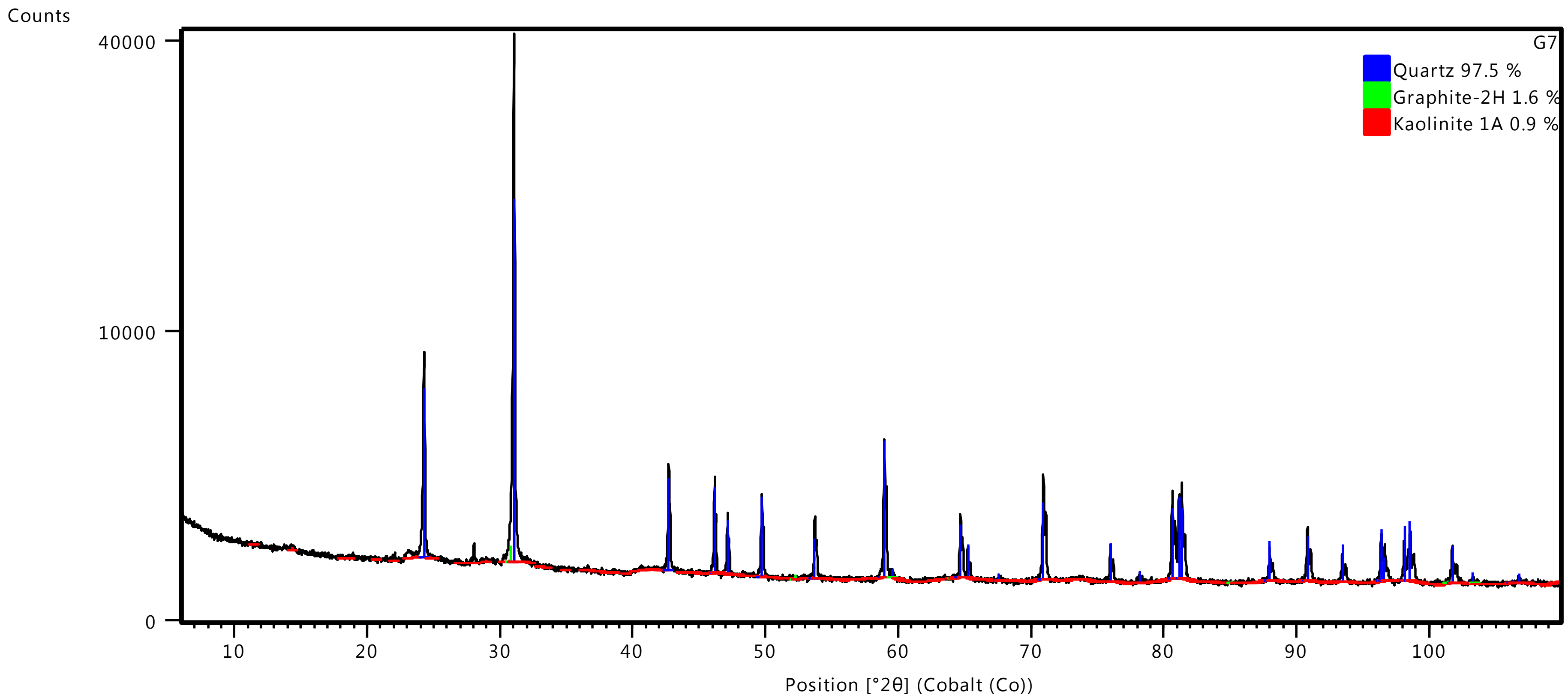
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



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Quartz 97.5 %
Graphite-2H 1.6 %
Kaolinite 1A 0.9 %
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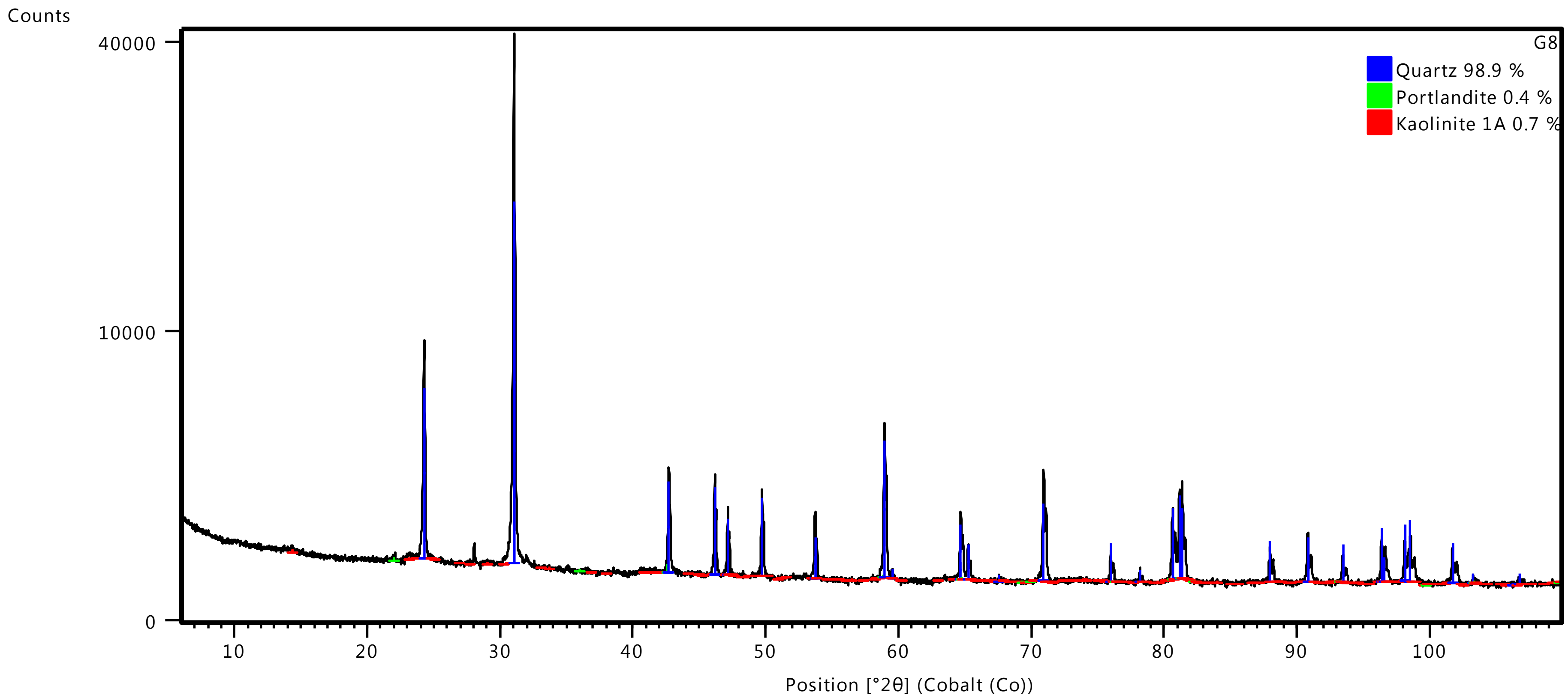
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



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G8
Quartz 98.9 %
Portlandite 0.4 %
Kaolinite 1A 0.7 %
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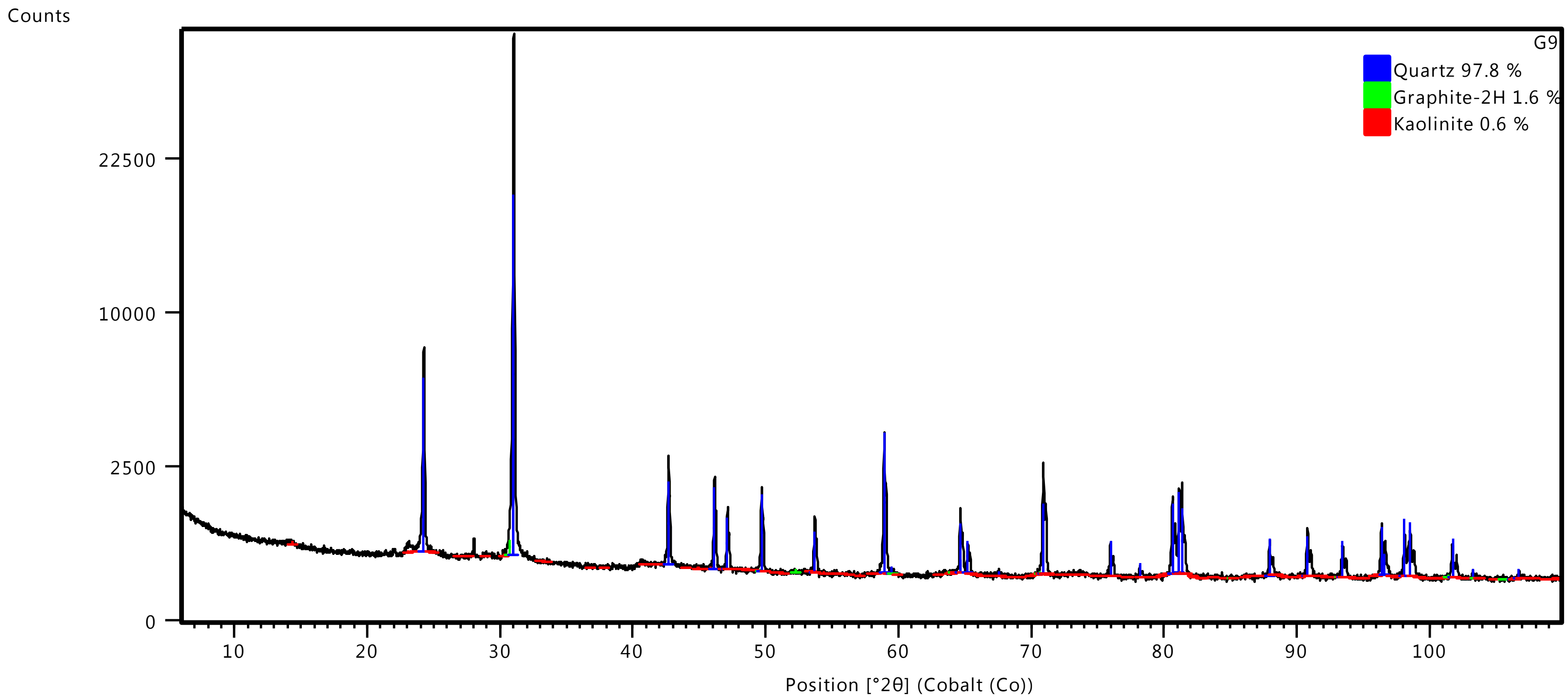
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



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Graphite-2H 1.6 %
Kaolinite 0.6 %
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10000
2500
0
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20
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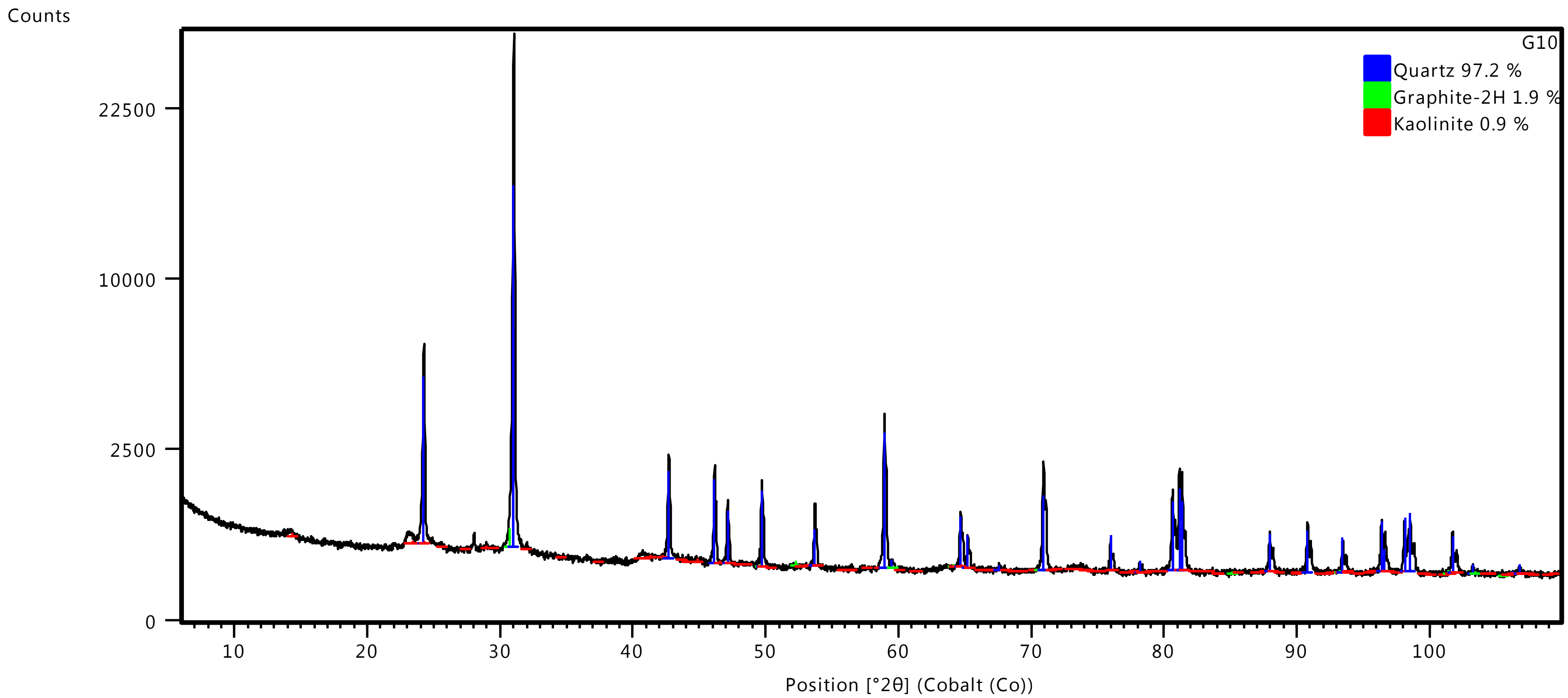
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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Graphite-2H 1.9 %
Kaolinite 0.9 %
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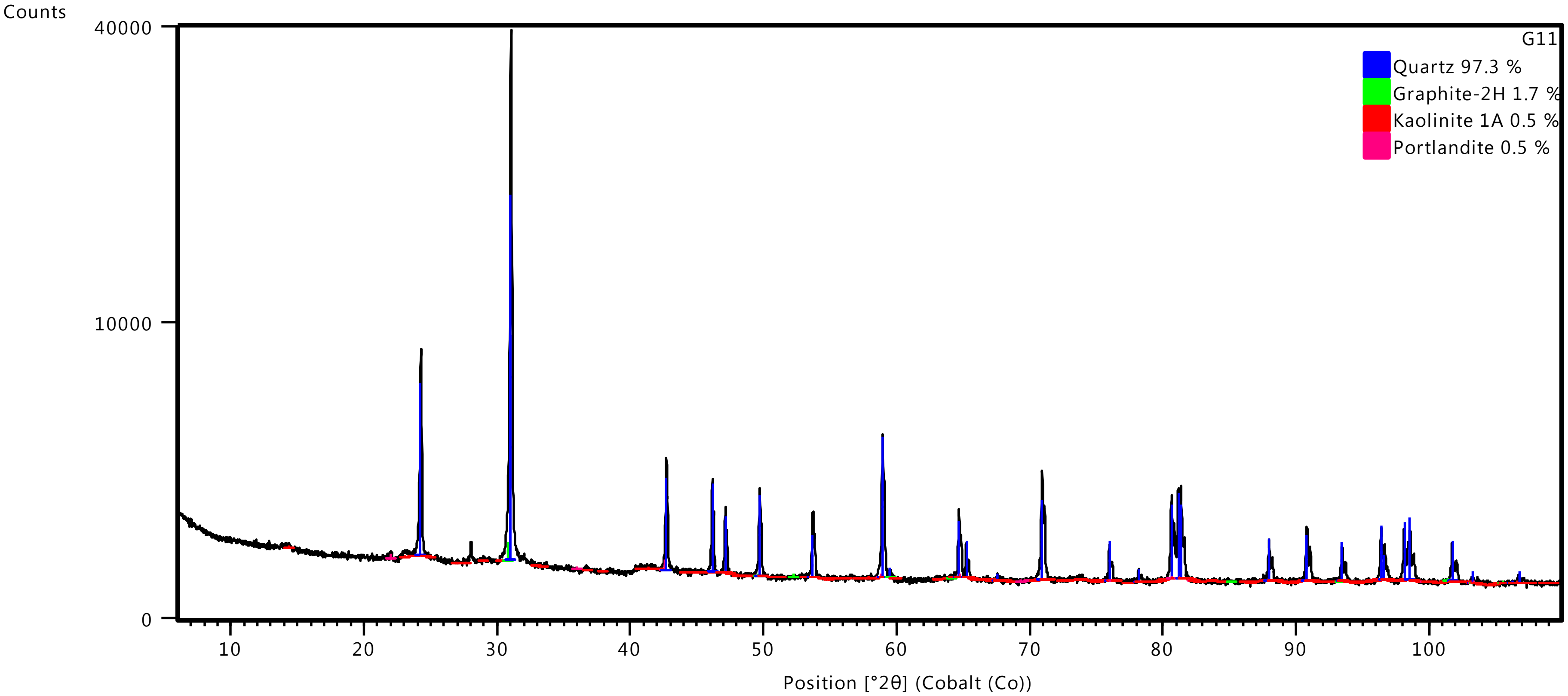
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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10000
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Quartz 97.3 %
Graphite-2H 1.7 %
Kaolinite 1A 0.5 %
Portlandite 0.5 %
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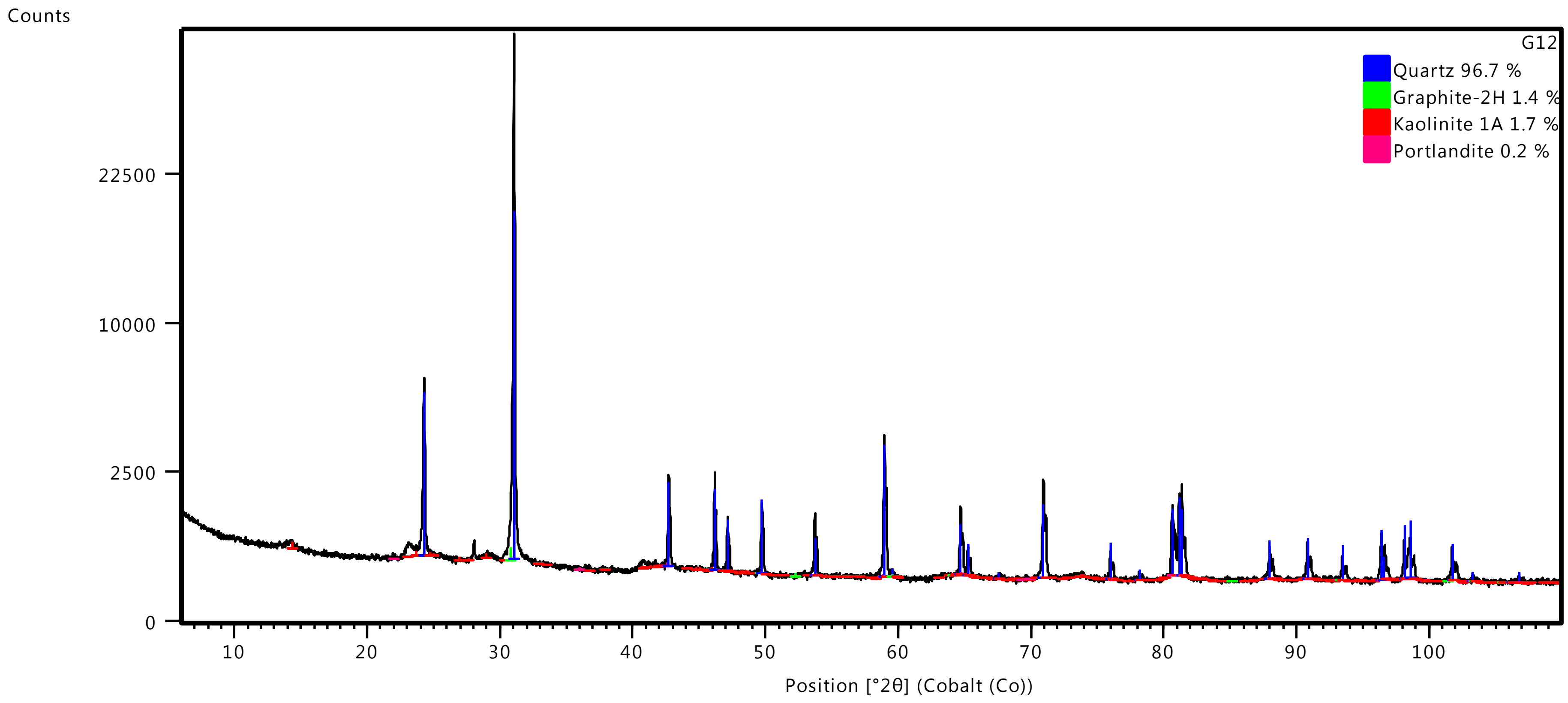
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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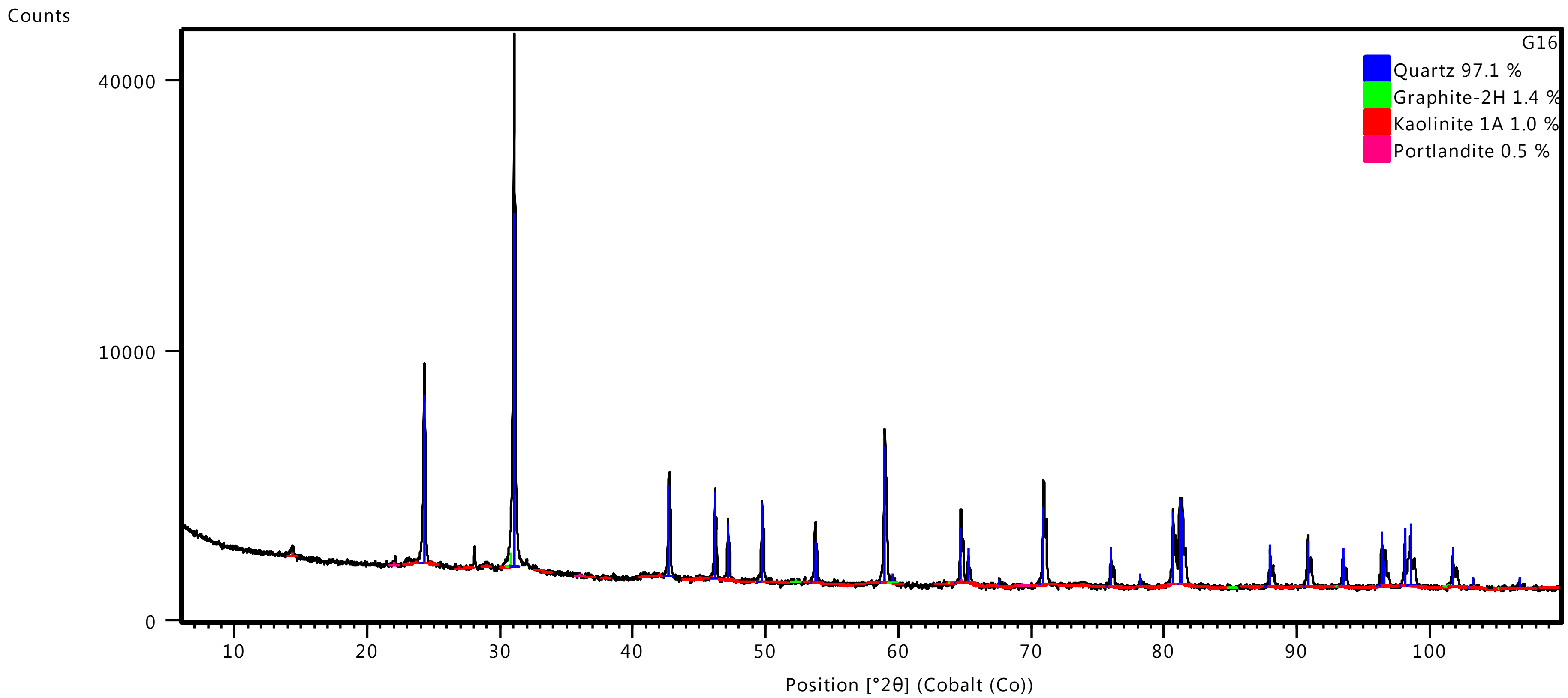
Graphite-2H 1.4 %
Kaolinite 1A 1.7 %
Portlandite 0.2 %
22500
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))


Counts
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10000
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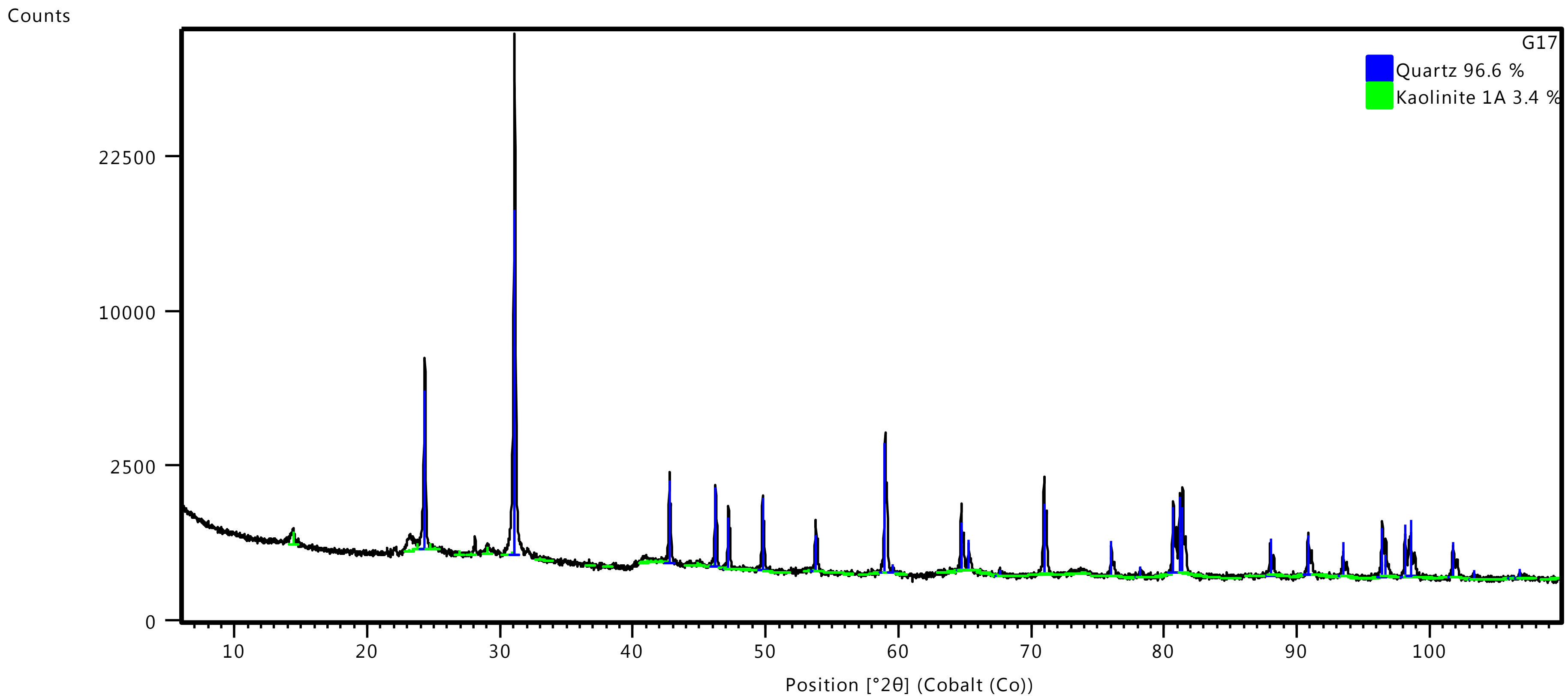
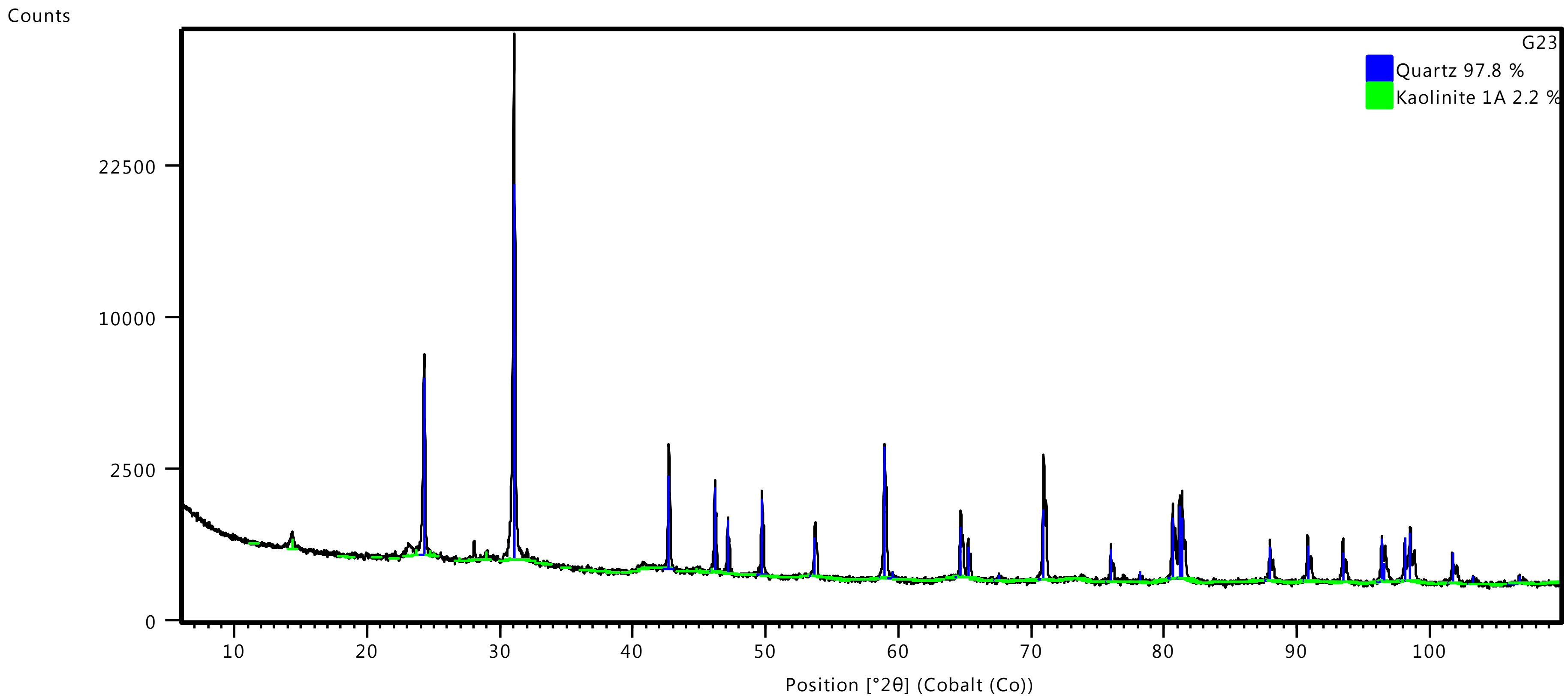
Quartz 97.1 %
Graphite-2H 1.4 %
Kaolinite 1A 1.0 %
Portlandite 0.5 %
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



Counts
G17
Quartz 96.6 %
Kaolinite 1A 3.4 %
22500
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))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Kaolinite 1A 2.2 %
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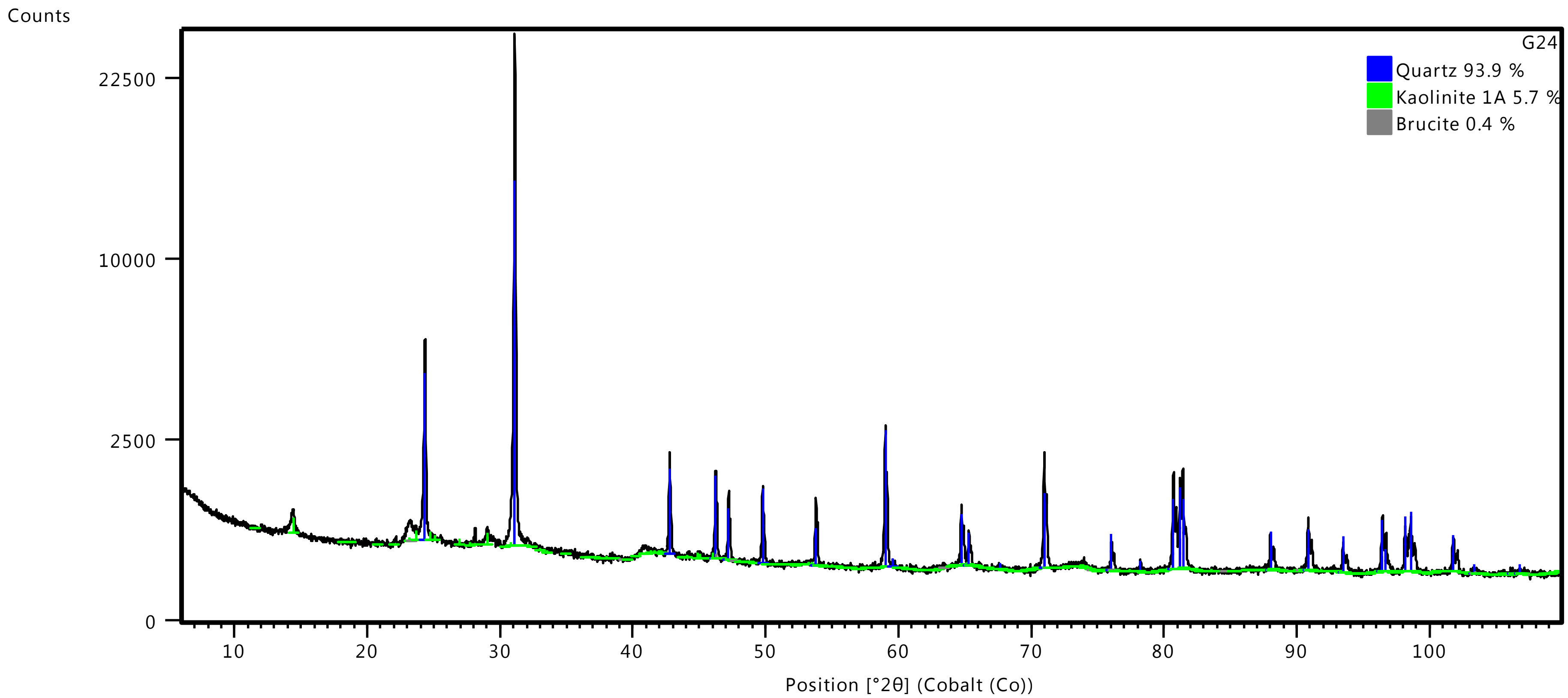
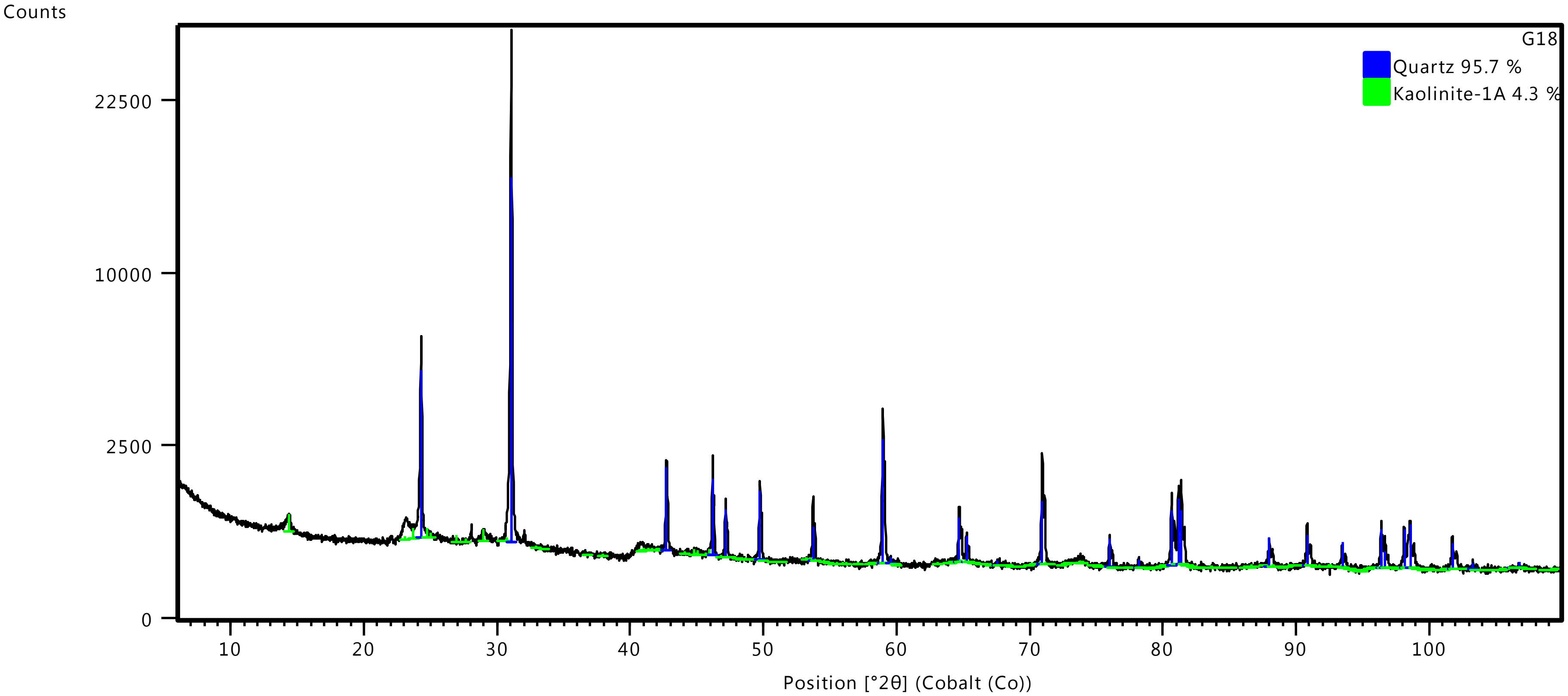
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))


Counts
22500
10000
2500
0
G24
Quartz 93.9 %
Kaolinite 1A 5.7 %
Brucite 0.4 %
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



Counts
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10000
2500
0
G18
Quartz 95.7 %
Kaolinite-1A 4.3 %
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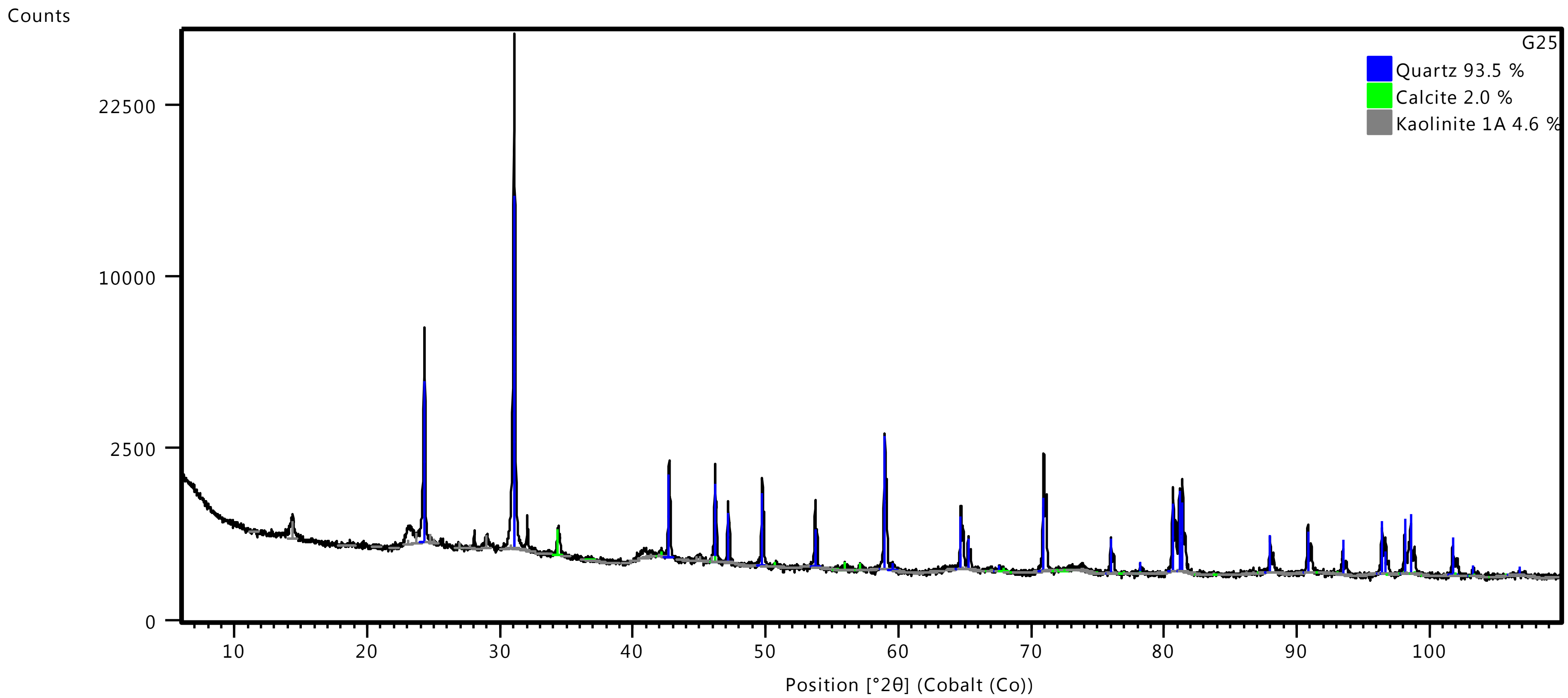
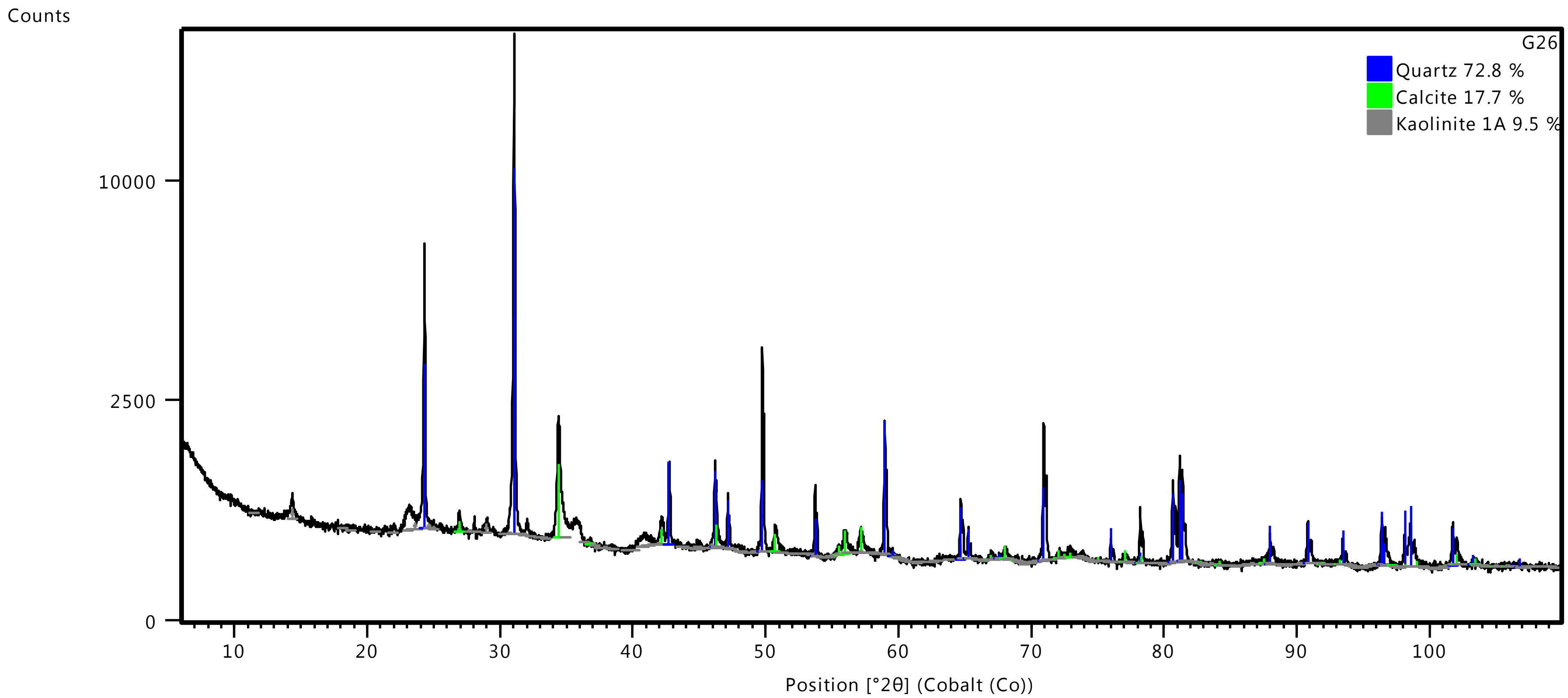
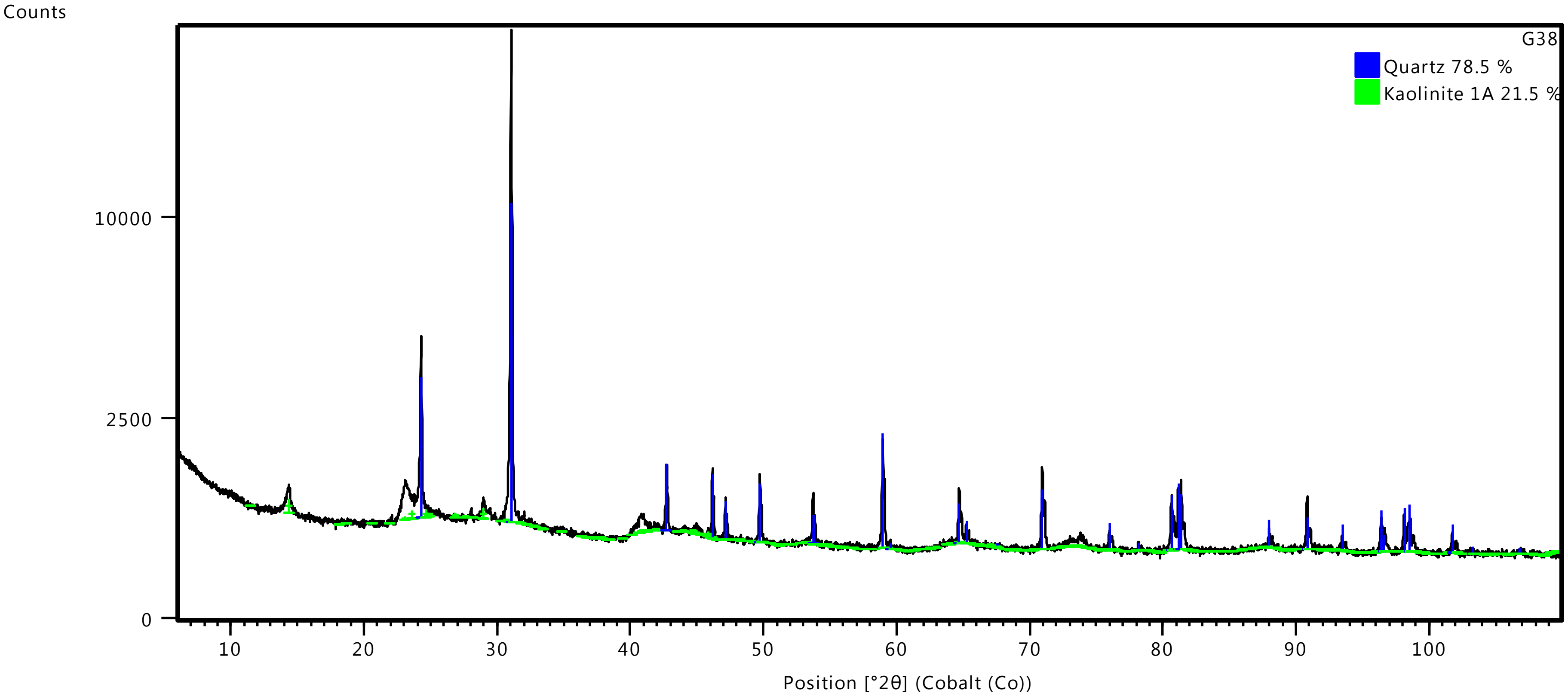
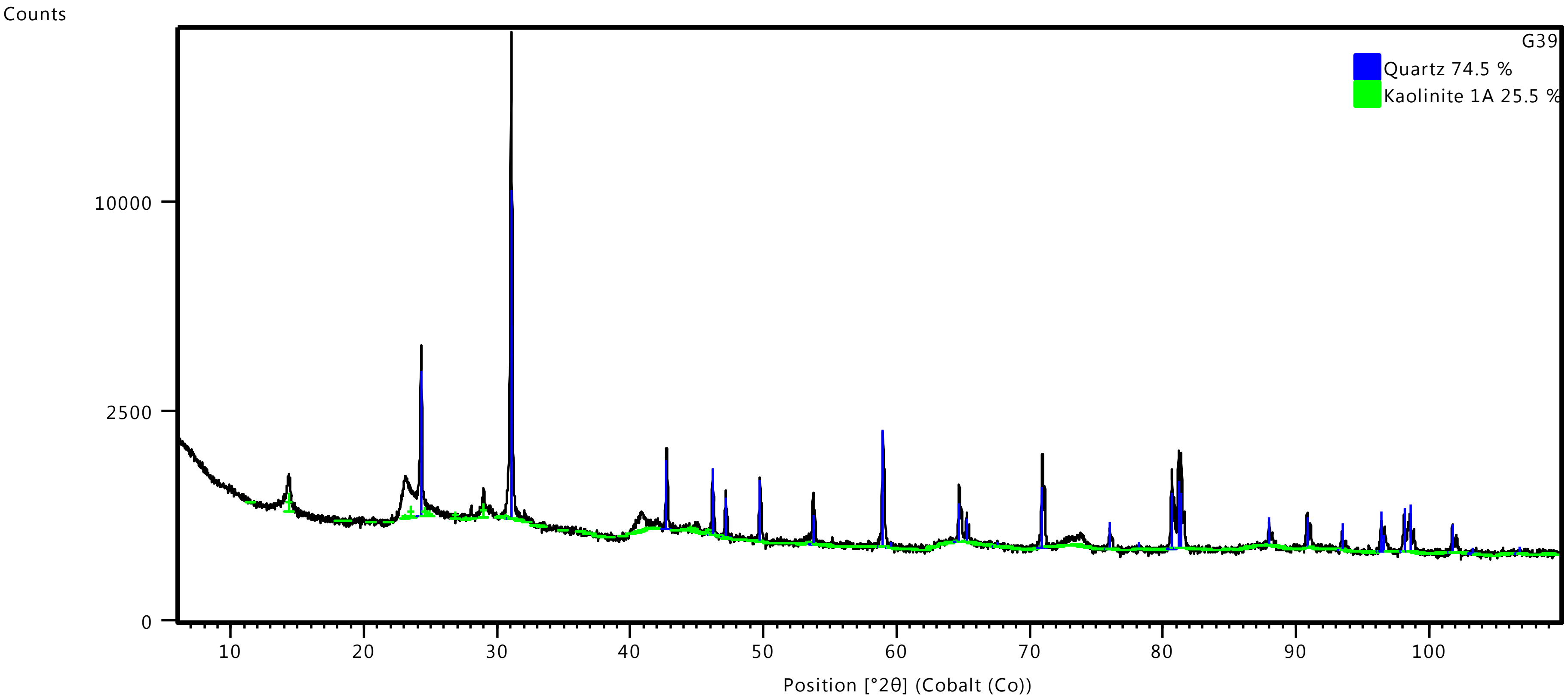
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



Counts
G25
Quartz 93.5 %
Calcite 2.0 %
Kaolinite 1A 4.6 %
22500
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))


Counts
G26
Quartz 72.8 %
Calcite 17.7 %
Kaolinite 1A 9.5 %
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))


Counts
G38
Quartz 78.5 %
Kaolinite 1A 21.5 %
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))



Counts
G39
Quartz 74.5 %
Kaolinite 1A 25.5 %
10000
2500
0
10
20
30
40
50
60
70
80
90
100
Position [°2θ] (Cobalt (Co))

APPENDIX D

Document Limitations

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