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A SPECIALIST REPORT ON THE SOILS, AGRICULTURAL POTENTIAL AND LAND CAPABILITY FOR THE DOORNHOEK FLUORSPAR MINING RIGHT APPLICATION IN THE NGAKA MODIRI MOLEMA DISTRICT, NORTH WEST PROVINCE

EOH

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SOILS AND LAND CAPABILITY REPORT

July 2015

Conducted on behalf of:

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Declaration

I, Barend Johannes Henning, declare that -

- I act as the independent specialist;
- I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the project proponent;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this project, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998; the Act), regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the project proponent and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the project; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority or project proponent;
- All the particulars furnished by me in this document are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

_____

Signature of specialist

Company: Exigo Sustainability (Pty) Ltd.

Date: July 2015

Notations and terms

Aerobic: Having molecular oxygen (O_2) present.

Agricultural means land zoned for agricultural use.

Anthropogenic: Of human creation

Arable means land that can produce crops requiring tillage; land so located and constituted that production of cultivated crops is economical and practical.

Alluvium (from the Latin, alluvius, from alluere, "to wash against") is loose, unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. When this loose alluvial material is deposited or cemented into a lithological unit, or lithified, it would be called an alluvial deposit.

Base status: A qualitative expression of base saturation. See base saturation percentage.

Black turf: Soils included by this lay-term are the more structured and darker soils such as the Bonheim, Rensburg, Arcadia, Milkwood, Mayo, Sterkspruit, and Swartland soil forms.

Biota: Living things; plants, animals, bacteria

Bottomland: The lowlands along streams and rivers, on alluvial (river deposited) soil.

Calcareous: Containing calcium carbonate.

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

Carbonate can refer both to carbonate minerals and carbonate rock (which is made of chiefly carbonate minerals), and both are dominated by the carbonate ion, CO_3^{2-}. Carbonate minerals are extremely varied and ubiquitous in chemically precipitated sedimentary rock. The most common are calcite or calcium carbonate, $CaCO_3$, the chief constituent of limestone (as well as the main component of mollusc shells and coral

skeletons); dolomite, a calcium-magnesium carbonate $CaMg(CO_3)_2$; and siderite, or iron(II) carbonate, $FeCO_3$, an important iron ore. Sodium carbonate ("soda" or "natron") and potassium carbonate ("potash") have been used since antiquity for cleaning and preservation, as well as for the manufacture of glass.

Chroma: The relative purity of the spectral colour, which decreases with increasing greyness.

Effective soil depth means the depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients; the depth to a layer that differs sufficiently from the overlying material in physical or chemical properties to prevent or seriously retard the growth of roots.

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

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

Fine sand: (1) A soil separate consisting of particles 0,25-0,1mm in diameter. (2) A soil texture class with fine sand plus very fine sand (i.e. 0,25-0,05mm in diameter) more than 60% of the sand fraction.

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

Floristic: of flora (plants).

Floodplain: Wetland inundated when a river overtops its banks during flood events resulting in the wetland soils being saturated for extended periods of time.

Gley: Soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but **mottles** (yellow, red, brown and black) may be present and indicate localised areas of better aeration.

High potential means prime or unique.

Horizon: See soil horizons.

Hydric soil: Soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hue (of colour): The dominant spectral colour (e.g. red).

Land means the total natural environment of the exposed part of the earth's surface, including atmosphere, climate, soils, vegetation and the cultural environment.

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

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

Land use: The use to which land is put.

Mottles: Soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Organic soil material: Soil material with a high abundance of undecomposed plant material and humus. According to the Soil Classification Working Group (1991) an organic soil horizon must have at least 10% organic carbon by weight throughout a vertical distance of 200 mm and be saturated for long periods in the year unless drained. According to the Soil Survey Staff (1975) definition, in order for a soil to be classed as organic it must have >12% organic carbon by weight if it is sandy and >18% if it is clay-rich.

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

Perched water table: The upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. Application may be seasonal.

Prime means the best land available, primarily from the national perspective, but with allowance of provincial perspectives; land best suited to, and capable of, consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseed), with acceptable expenditure of energy and economic resources and minimal damage to the environment (and is available for these uses).

Seasonally wet soil: Soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.

Sedges: Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

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

Soil drainage classes describe the soil moisture conditions as determined by the capacity of the soil and the site for removing excess water. The classes range from very well drained, where excess water is removed very quickly, to very poorly drained, where excess water is removed very slowly. Wetlands include all soils in the very poorly drained and poorly drained classes, and some soils in the somewhat poorly drained class. These three classes are roughly equivalent to the permanent, seasonal and temporary classes

Soil family means a defined subdivision of a soil form representing a greater degree of uniformity than the form itself.

Soil form means the highest category in the South African soil classification system; soil forms are defined in terms of kind and sequence of diagnostic horizons; the soil form implies, inter alia, physical and hydrological properties which provide an indication of land-use possibilities and constraints; In the 1991 Edition, titled "Soil Classification: A Taxonomic System For South Africa", 73 soil forms are recognized.

Soil horizons: Layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil profile: The vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991).

Soil saturation: The soil is considered saturated if the water table or **capillary fringe** reaches the soil surface (Soil Survey Staff, 1992).

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

Temporarily wet soil: The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Terrain unit classes: Areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5).

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

Topsoil clay content means the average percentage clay-sized material (<0.002 mm) in the uppermost part of the soil; that is, the part ordinarily moved in tillage, or its equivalent in uncultivated soils, ranging in depth from about 100 to 300 mm; frequently designated as the “plough layer” or the “Ap horizon”.

Unique agricultural land means land that is or can be used for producing specific high-value crops. It is usually not prime, but important to agriculture due to a specific combination of location, climate or soil properties that make it highly suited for a specific crop when managed with specific farming or conservation methods. Included is agricultural land of high local importance where it is useful and environmentally sound to encourage continued agricultural production, even if some or most of the land is of mediocre quality for agriculture and is not used for particularly high-value crops.

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

Water regime: When and for how long the soil is flooded or saturated**.**

List of abbreviations

Abbreviation	Description
ARC	Agricultural Research Council
CARA	Conservation of Agricultural Resources Act
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DENC	Department of Environmental Affairs and Nature Conservation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme Report
ENPAT	Environmental Potential Atlas
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information Systems
GPS	Geographical Positioning System
ISCW	Institute for Soil, Climate and Water
MAE	Mean Annual Evaporation
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NC	Northern Cape
NEMA	National Environmental Management Act
PQ4	Priority Quaternary Catchment
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
WHO	World Health Organisation

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1 ASSIGNMENT

Exigo Sustainability was appointed by SA Fluorite / ENPRC to conduct a soil potential and land capability study as part of the EIA phase (Mining Right Application) for the proposed establishment of the Doornhoek Fluorspar Mine. The project involves the development of opencast mining sections, a processing plant as well as associated infrastructure (e.g. access roads, tailings storage facility, overburden dumps etc.). The proposed activities/infrastructure will be located on portions of the farms 306 JP, Knoflookfontein 310 JP and Rhenosterfontein 304 JP. The farms are currently zoned as agriculture. The project area is located in the Zeerust area, Ditsobotla Local Municipality, Ngaka Modiri Molema District Municipality, North West Province (see figure 1).

The main purpose of this study was solely to assess the agricultural potential and value of the soil types on the site. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in compliance with Regulation 387 of 21 April 2006, promulgated in terms of Section 24 (5) of NEMA.

The assignment is interpreted as follows: Compile a study on the soil potential of the soil forms of the proposed development site according to guidelines and criteria set by the National Department of Agriculture. The study will include a detailed soil assessment and interpretation. In order to compile this, the following had to be done:

1.1 Information Sources

The following information sources were obtained:

- All relevant maps through GIS mapping, and information (previous studies and agricultural databases) on the land use, soils, agricultural potential and land capability of the area concerned;
- Requirements regarding the agricultural potential survey and prime or unique agricultural land as requested by the NDA;
- Obtain relevant information of land type, geology and soil types of the area. This includes information on the soil potential, clay percentage, soil depth and soil forms, as classified by the Environmental Potential Atlas of South Africa (Institute for Soil, Climate and Water, Agricultural Research Institute);
- Obtain information of the prevailing land use and agricultural activities being practiced in the larger area of the neighbouring properties;
- Obtain an aerial photograph of the area to help in the interpretation and identification of major soil types and land uses in the study area.

1.2 Regulations governing this report

1.2.1 National Environmental Management Act, 1998 (Act No. 107 of 1998) - Regulation No. R982

This report was prepared in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Gazette No. 38282 Government Notice R. 982. Appendix 6 – Specialist reports includes a list of requirements to be included in a specialist report:

1. A specialist report or a report prepared in terms of these regulations must contain:
    a. Details of
        i. The specialist who prepared the report; and
        ii. The expertise of that specialist to compile a specialist report, including a curriculum vitae;
    b. A declaration that the specialist is independent in a form as may be specified by the competent authority;
    c. An indication of the scope of, and purpose for which, the report was prepared;
    d. The date and season of the site investigation and the relevance of the season to the outcome of the assessment;
    e. A description of the methodology adopted in preparing the report or carrying out the specialized process;
    f. The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;
    g. An identification of any areas to be avoided, including buffers;
    h. A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;
    i. A description of any assumptions made and any uncertainties or gaps in knowledge;
    j. A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;
    k. any mitigation measures for inclusion in the EMPr;
    l. any conditions for inclusion in the environmental authorisation;

m. any monitoring requirements for inclusion in the EMPr or environmental authorisation

n. a reasoned opinion –

   i. As to whether the proposed activity or portions thereof should be authorised and

   ii. If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr and where applicable, the closure plan;

o. A description of any consultation process that was undertaken during the course of preparing the specialist report;

p. A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and

q. Any other information requested by the competent authority.

1.2.2 Other related legislation

The natural resources of South Africa constitute a national asset, which is essential for the economic welfare of present and future generations. Economic development and national food security depend on the availability of productive and fertile agricultural land, and are threatened by the demand for land for residential and industrial development. Urban and rural planning needs to be integrated rather than sectorial and fragmentary. The use of agricultural land for other purposes should therefore be minimised. Currently the retention of productive agricultural land is administrated through the SUBDIVISION OF AGRICULTURAL LAND ACT, 1970 (ACT NO. 70 OF 1970) which controls the subdivision of agricultural land and its use for purposes other than agriculture. In the near future the use of these scares resources will be regulated through the SUSTAINABLE UTILISATION of AGRICULTURAL RESOURCES BILL. One of the object of the new Bill is to provide for the use and preservation of agricultural land, especially “prime and unique agricultural land” by means of prescribe criteria in terms of which agricultural land may be used for purposes other than agriculture, in collaboration with principles as laid down in the Development Facilitation Act, 1995 (Act No. 67 of 1995) and also in collaboration with the Land Use Bill, 2001. The prescribe criteria shall relate to the importance of the continued use of those agricultural resources for agricultural purposes in general particularly taking into consideration the use of prime and unique agricultural land or its agricultural importance relative to a particular province or area. Different criteria may be prescribed from time to time and such criteria may differ from province and area.

1.3 Terms of reference

1.3.1 The Doornhoek Project: Background information

The Doornhoek Project has the potential to contain in excess of 50 million tonnes of fluorspar and is believed to be one of the world's largest fluorspar deposits. The underground ore body has grades more than double that of the adjoining Sallies Witkop Mine and resources sufficient to justify an initial life of mine in excess of 20 years.

The Doornhoek Project is currently in exploration phase and based on a request from the Department of Mineral Resources to quantify the groundwater use and potential exploration impacts on the groundwater resources.

The planned infra-structure for the mining operations is as follows:

1. Opencast and underground mining to depths of 90m;
2. Overburden dumps;
3. Minerals processing plant;
4. Tailings facility;
5. Haul roads and offices;
6. Water supply pipelines;

Electrical reticulation and sub-stations.

1.3.2 Objectives

The objectives of this report are as follows:

- Conduct a soil survey on the proposed development site and identify the different soil types / forms present on the site;
- From the soil survey results link the optimal land use and other potential uses and options to the agricultural potential of the soils by classifying the soils into different Agricultural Potential classes according to the requirements set by the Department of Agriculture, South Africa. From these results soils maps and an agricultural potential map will be compiled;
- Discussion of the agricultural potential and land capability in terms of the soils, water availability, grazing capacity, surrounding developments and current status of land.
- Identify potential impacts of the development on the soils and provide mitigation measures to manage these impacts.

1.3.3 Limitations and assumptions

- In order to obtain a comprehensive understanding of the dynamics of the soils of the study area, surveys should ideally be replicated over several seasons and over a number of years. However, due to project time constraints such long-term studies are not feasible;
- The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative, homogenous sections of soils, as well as general observations, aerial photograph analysis, generic data and a desktop analysis;

2 STUDY AREA

2.1 LOCATION

The Doornhoek Fluorspar Mine is located in the North West Province of South Africa, approximately 15 km southeast of the town of Zeerust along the R510 provincial road to Koster and falls within the Ditsobotla Local Municipality, Ngaka Modiri Molema District Municipality (Figure 1). Due to poor international market conditions it will be necessary to gradually phase in the mining activities, and to divide the mining activities into two phases. The first phase will take place on portions of Rhenosterfontein 304 JP, and the second phase will take place on portions of the Farm 306 JP. The mine surface infrastructure is proposed to be located on the above farms. Additional mineral resources are also located on surrounding farms within the mining right area. The area is drained to the north by the Klein Marico River and a number of associated tributaries. The aerial image of the project area is included in figure 2, while the detailed layout map alternatives for the plant and TSF are indicated in Figure 4 to 7.

Physical mining will only begin in year 5 after mining license has been granted. Road and plant construction will take place in the years before this. Ore will be mined from year 5-10 from area shown in Figure 4 below, estimated to contain approximately 3.2Mt of ore. Year 10-15, 15-20 and 20-30 mining will take place on the farm 306JP owned by the company (Figure 3).

Labour will be sourced from the local community as far as possible, and is planned to be accommodated in the town of Zeerust.

Envisaged infrastructure will comprise of the following:

- Opencast mine development;
- Overburden and topsoil stockpiles;
- Concentrator (processing) plant and related infrastructure (a alternatives Figure 4-7);
- Haul, maintenance and access roads;
- Storm water management infrastructure (compliance GN704);
- Buildings (admin, offices, change house, stores, workshops etc);
- Diesel storage tanks;
- Water supply pipelines;
- Electricity supply High tension (HT) power lines;
- Tailings disposal facility; and
- Water reservoirs and settling ponds.

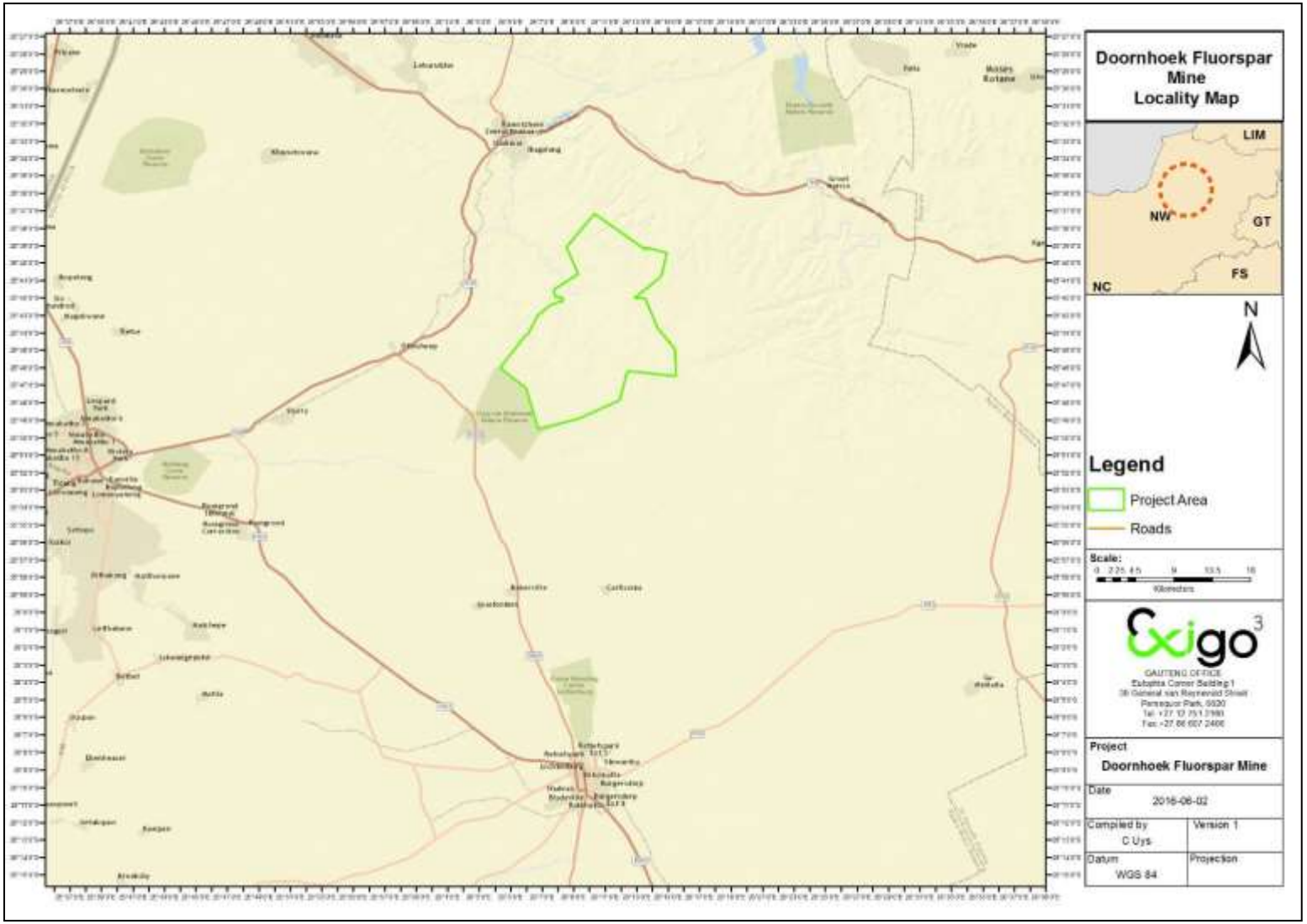


Figure 1. Regional Location Map

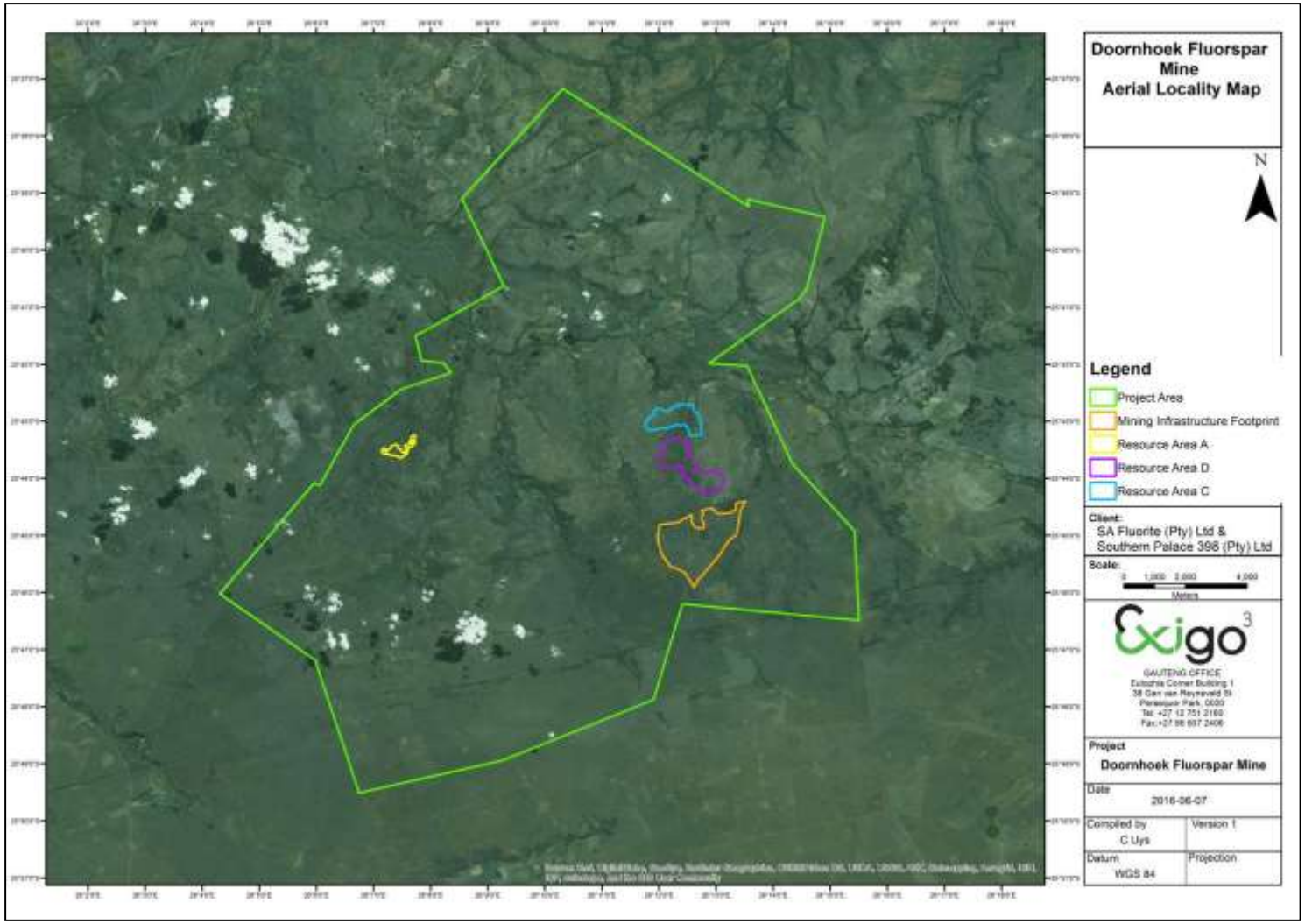


Figure 2. Satelite image showing the project area (Google Pro, 2010)

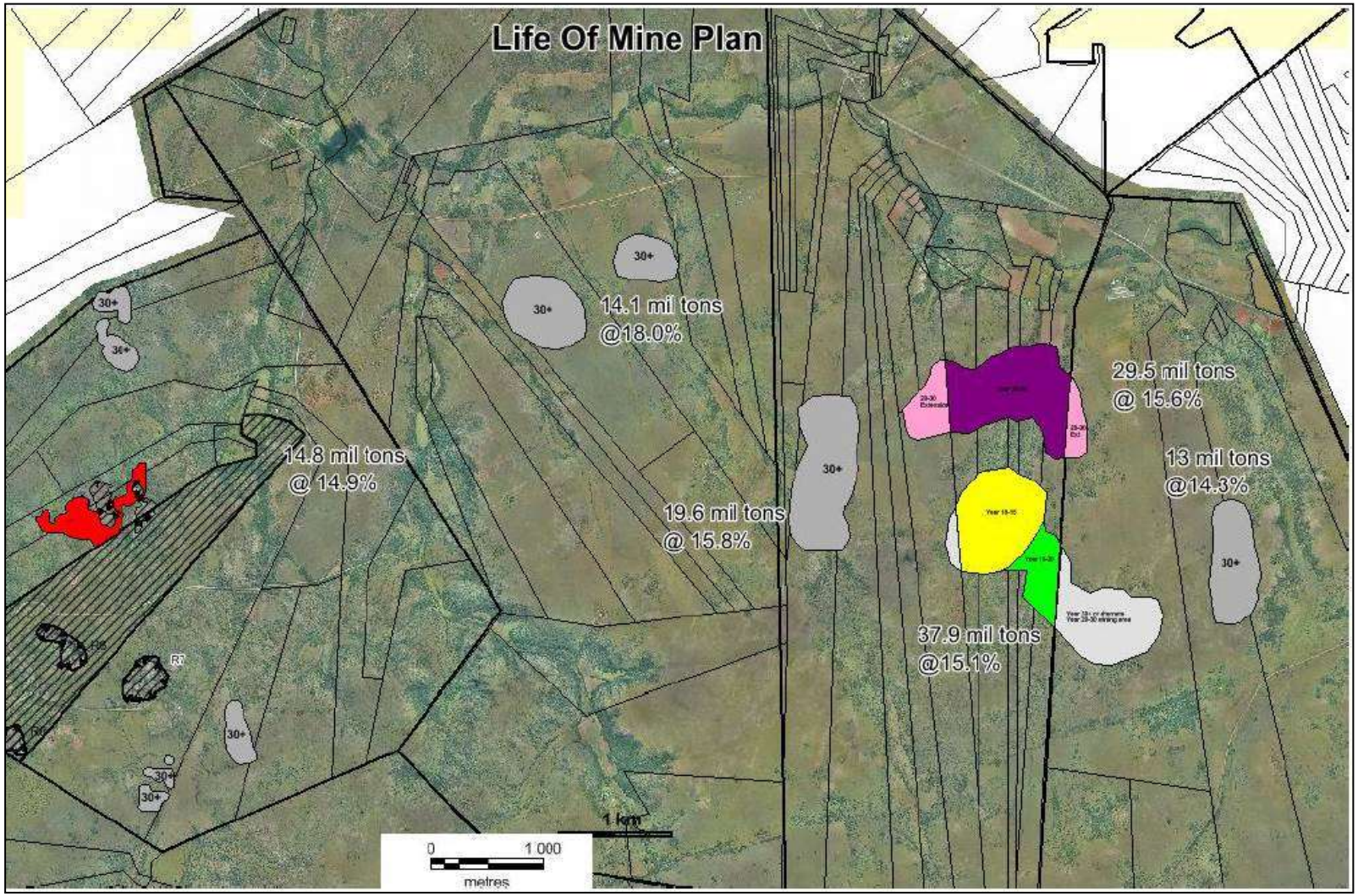


Figure 3. Open Pit Mining Schedule

Doornhoek Fluorspar Mine Soil Impact Assessment

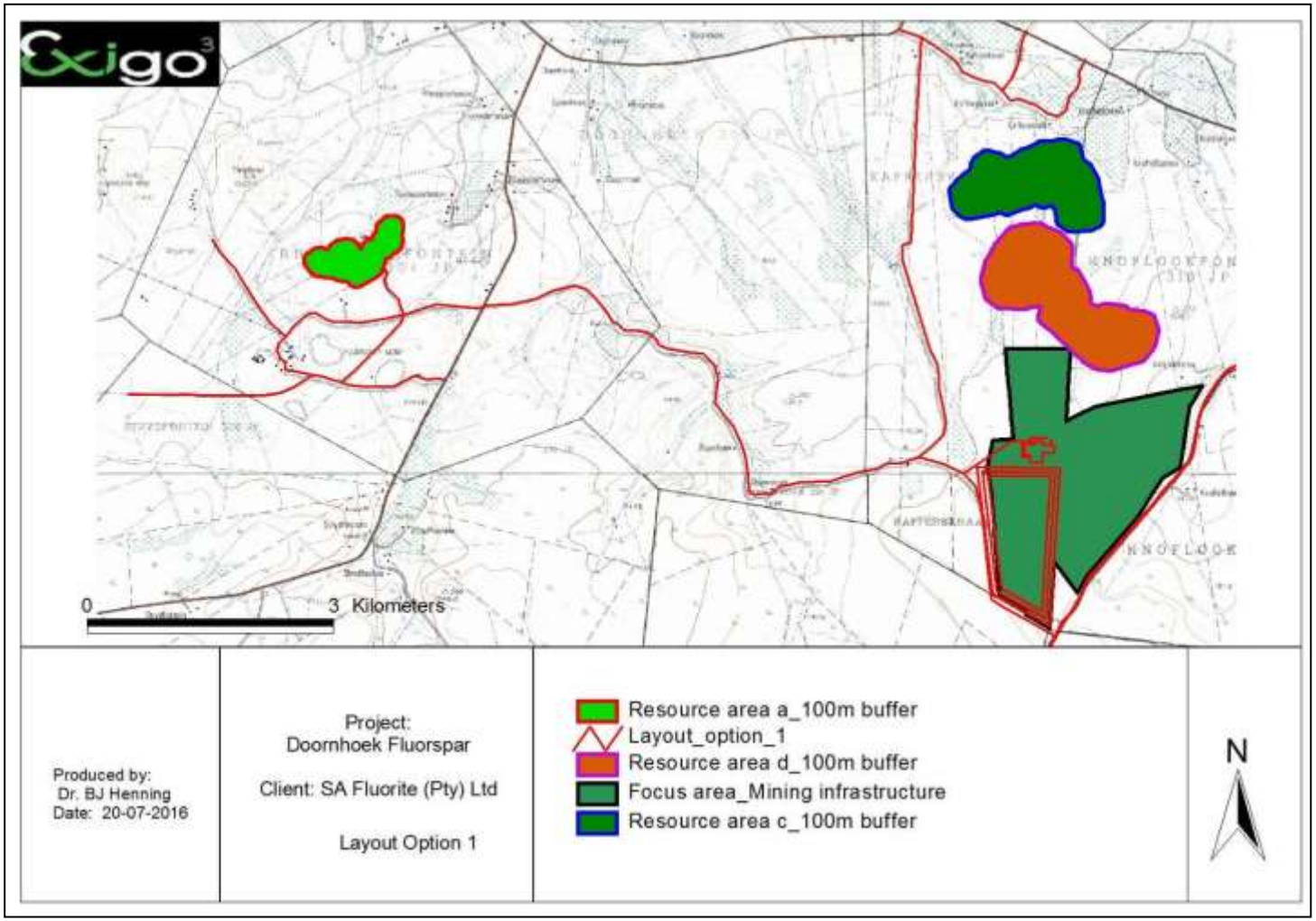


Figure 4.Layout option 1 for the mining infrastructure of the Doornhoek Fluorspar Mine

Doornhoek Fluorspar Mine Soil Impact Assessment

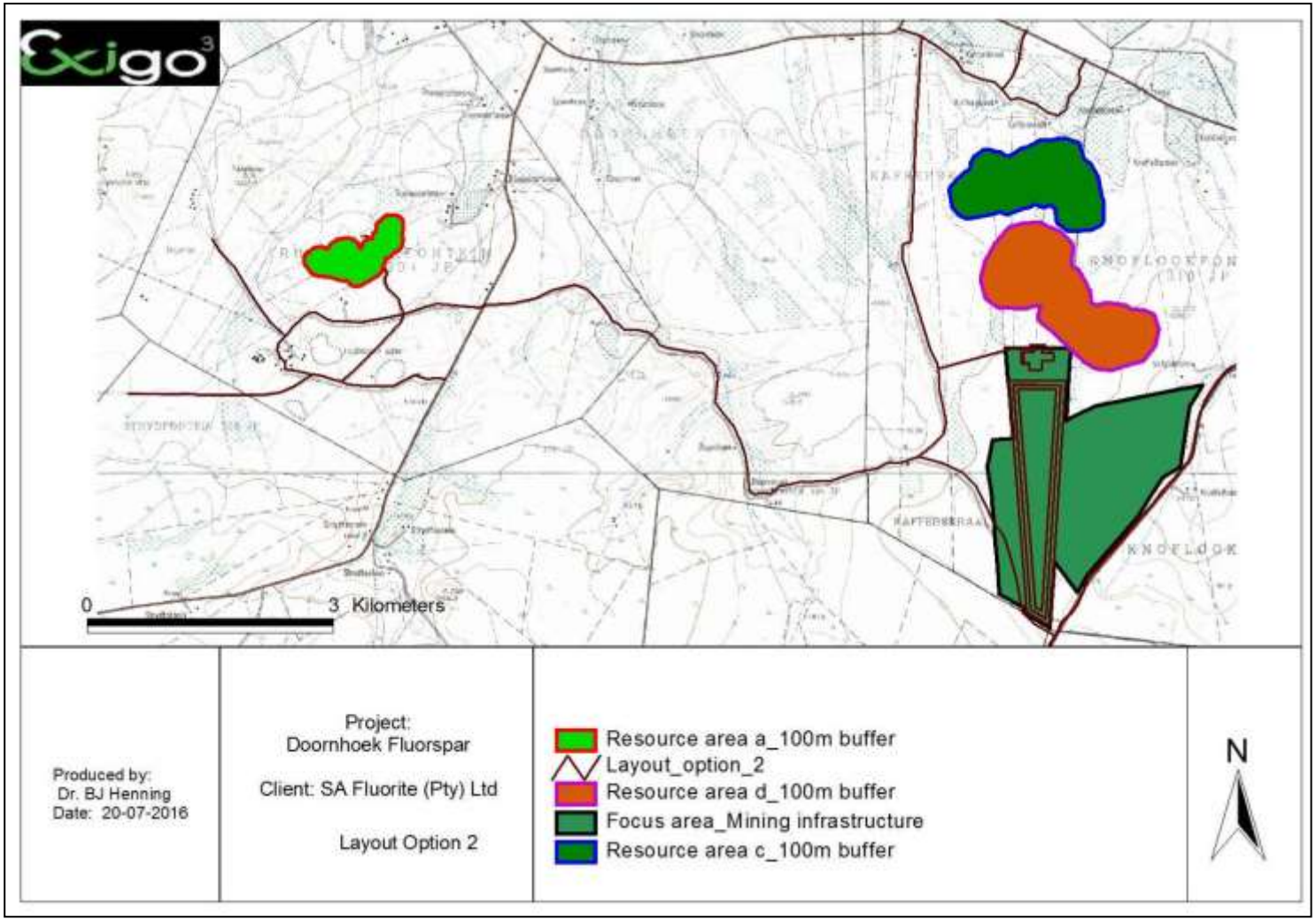


Figure 5. Layout option 2 for the mining infrastructure of the Doornhoek Fluorspar Mine

Doornhoek Fluorspar Mine Soil Impact Assessment

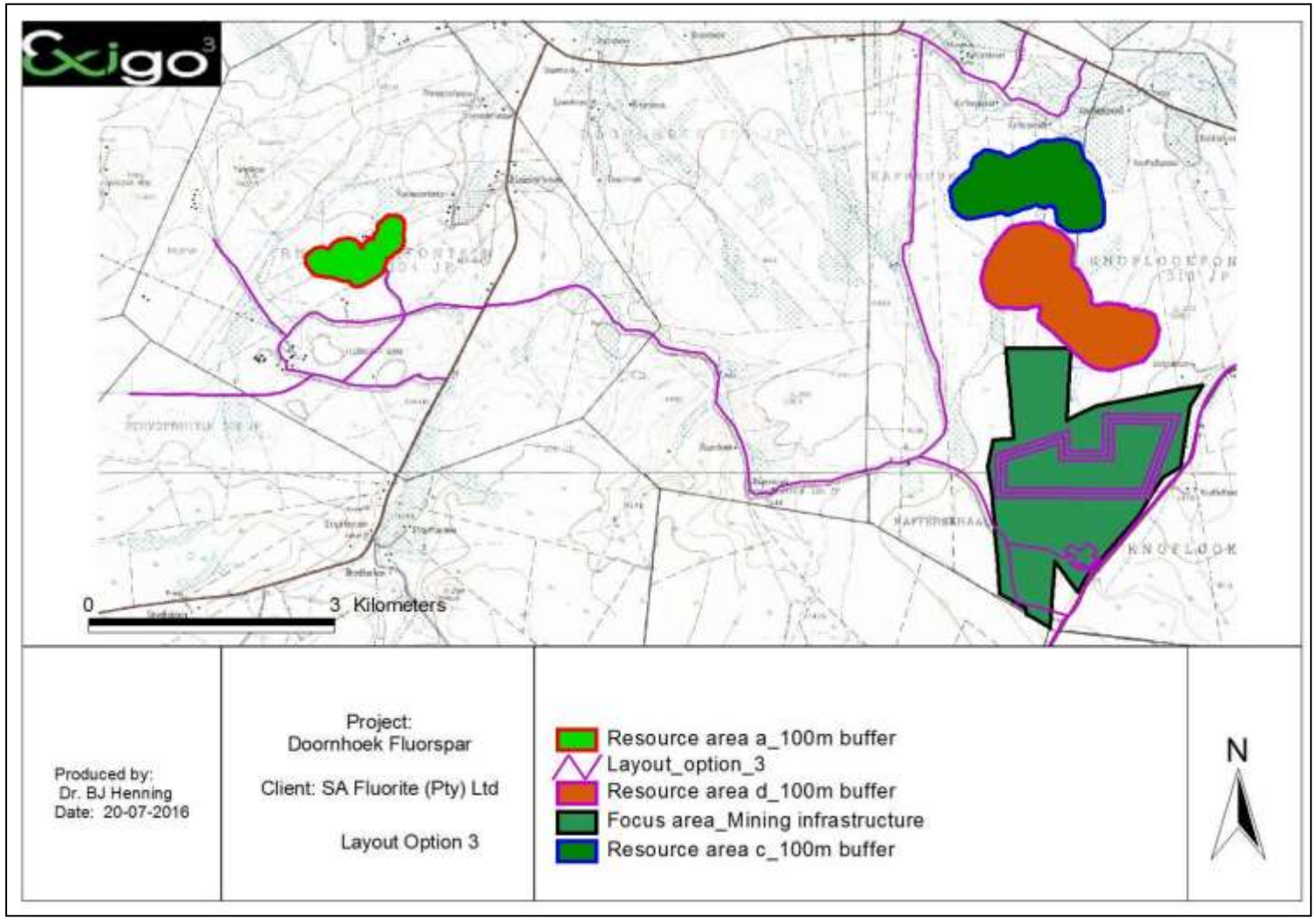


Figure 6. Layout option 3 for the mining infrastructure of the Doornhoek Fluorspar Mine

Doornhoek Fluorspar Mine Soil Impact Assessment

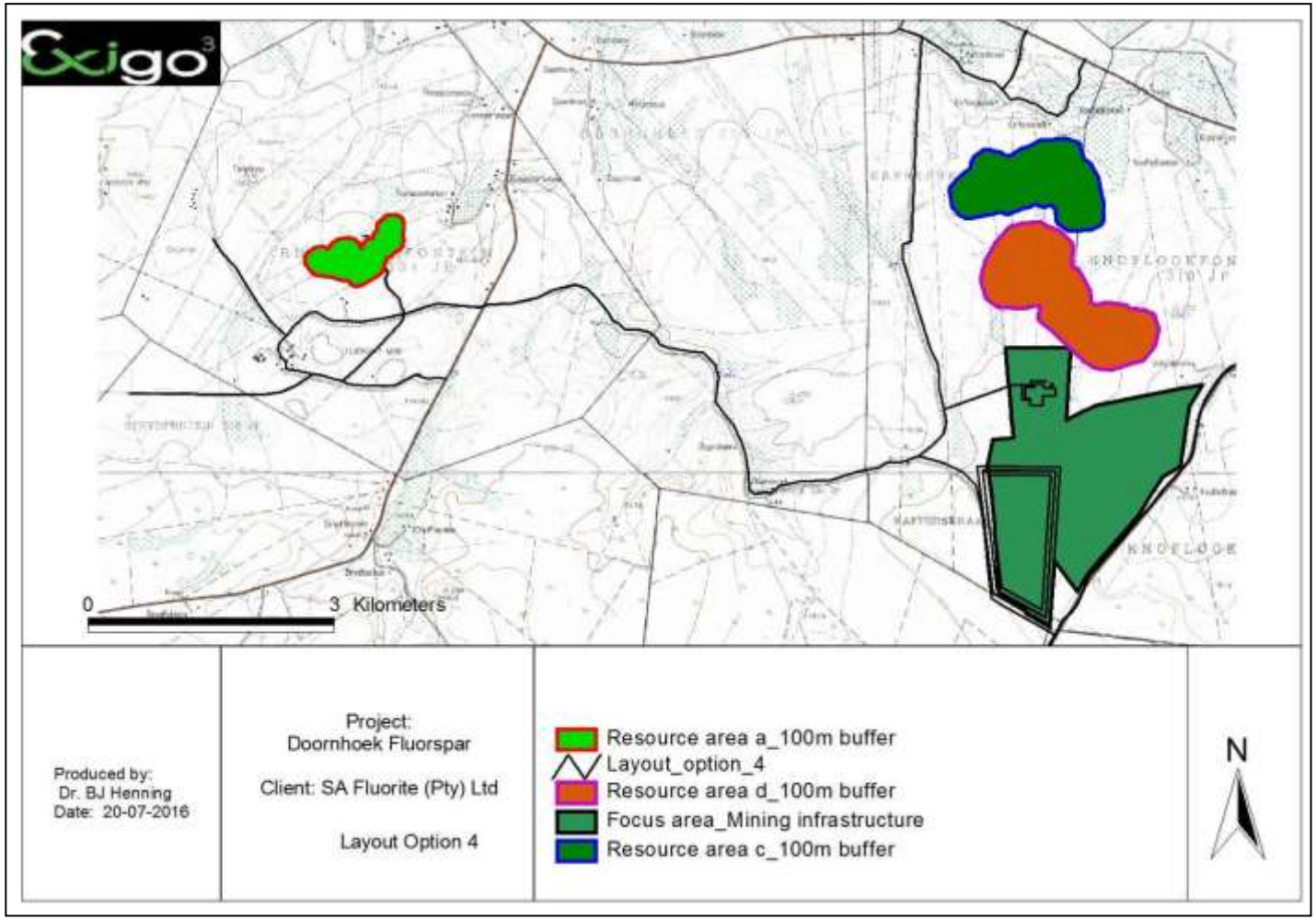


Figure 7. Layout option 4 for the mining infrastructure of the Doornhoek Fluorspar Mine

2.2 CLIMATE

Solar radiation, temperature, and precipitation are the main drivers of crop growth; therefore agriculture has always been highly dependent on climate patterns and variations. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, resulting in higher global temperatures, affecting hydrological regimes and increasing climatic variability. Climate change is projected to have significant impacts on agricultural conditions, food supply, and food security.

2.2.1 Rainfall & Temperature

In this report, climate refers to the summation of the daily, weekly and monthly changes of weather over a long period and it is influenced by latitude, altitude, direction and intensity of wind and the presence of large bodies of water such as the ocean, lakes, dams and rivers. The main climatic factors analysed for the site were long-term monthly average rainfall, temperature and relative humidity.

The area known as the Bankeveld, which occur in portions of Zeerust and Marico, can be separated from the Highveld region on the grounds of the differences shown in its climatic statistics. The project site has warm to hot summers and cool and dry to cold winters, with an average annual rainfall of 439mm. According to Groundwater Resource Directed Measures (GRDM) the Mean Annual Precipitation (MAP) is 566mm/a and the Mean Annual Runoff is 8mm/a for the entire catchment. The Mean Annual Evaporation (MAE) is 8mm/a.

The average maximum temperatures for the region have been recorded between November and January, with temperatures reaching a maximum of 31°C. The average minimum temperatures are reached during June and July with a minimum temperature of 1°C.

The rainfall pattern of Marico catchments is highly variable and unevenly distributed within the catchments. The intermittence of the rainfall results in frequent floods and local droughts.

As far as the temperatures are concerned it is noticeable that the daily average maximums are all more than 30.3ºC, while the minimum for Zeerust is below 0˚C. The absolute maximum temperature of Zeerust is in excess of 40.6ºC. The absolute minimums recorded varies between -3,3ºC and -7,8ºC.The days with temperatures below freezing is still in the order of 23 to 32, but days with temperatures of less than -2,5ºC are less than on the Highveld.

As far as precipitation is concerned it is noticeable that the averages are all in excess of 600mm. Zeerust receives on average 57.1 days with thunder and only 1,1 days with hail.

Figure 8 indicates the monthly climatic averages of the project area, while Table 1 indicate the

temperature, precipitation and humidity levels for the Zeerust and Mafikeng weather stations :

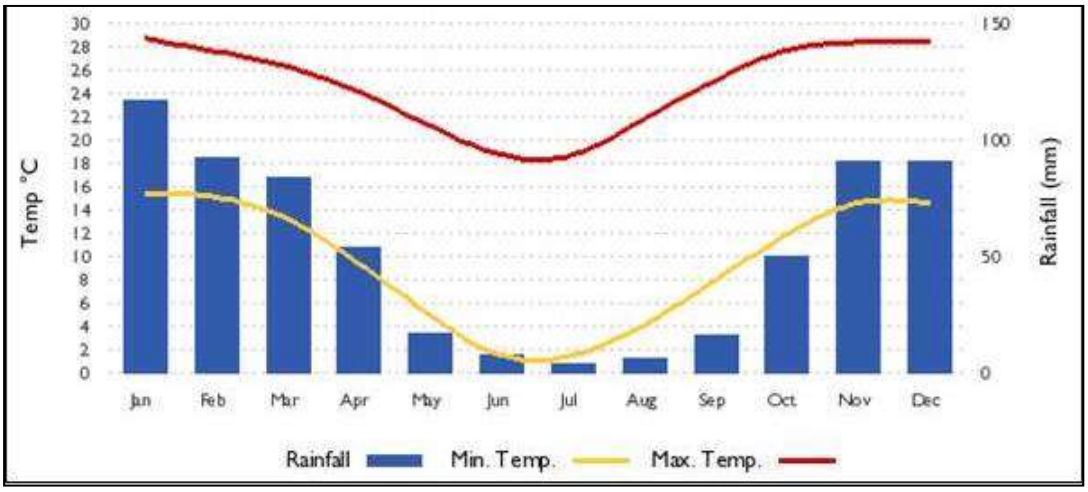


Figure 8. Monthly climatic averages for the project area

Table 1. Temperature, precipitation and humidity levels for the weather stations of the project area (Source: South African Weather Bureau)

STATIONS:	MEAN TEMPERATURES (ºC)		PRECIPITATION (mm)			MEAN RELATIVE HUMIDITY (%)	
	JAN	JUL	MEAN	HIGH	LOW	JAN	JUNE
MAFIKENG	30,4	3,0	553	868	265	65	35
ZEERUST	30,8	-0,8	600	1002	390	69	36

2.2.2 Wind

The long-term weather record indicates that wind speed, experienced in the project area from 0 to more than 10.0 ms-1. The maximum wind speed rarely rises beyond 10 ms-1. Figure 9 indicate the seasonal variations of the wind direction and speed.

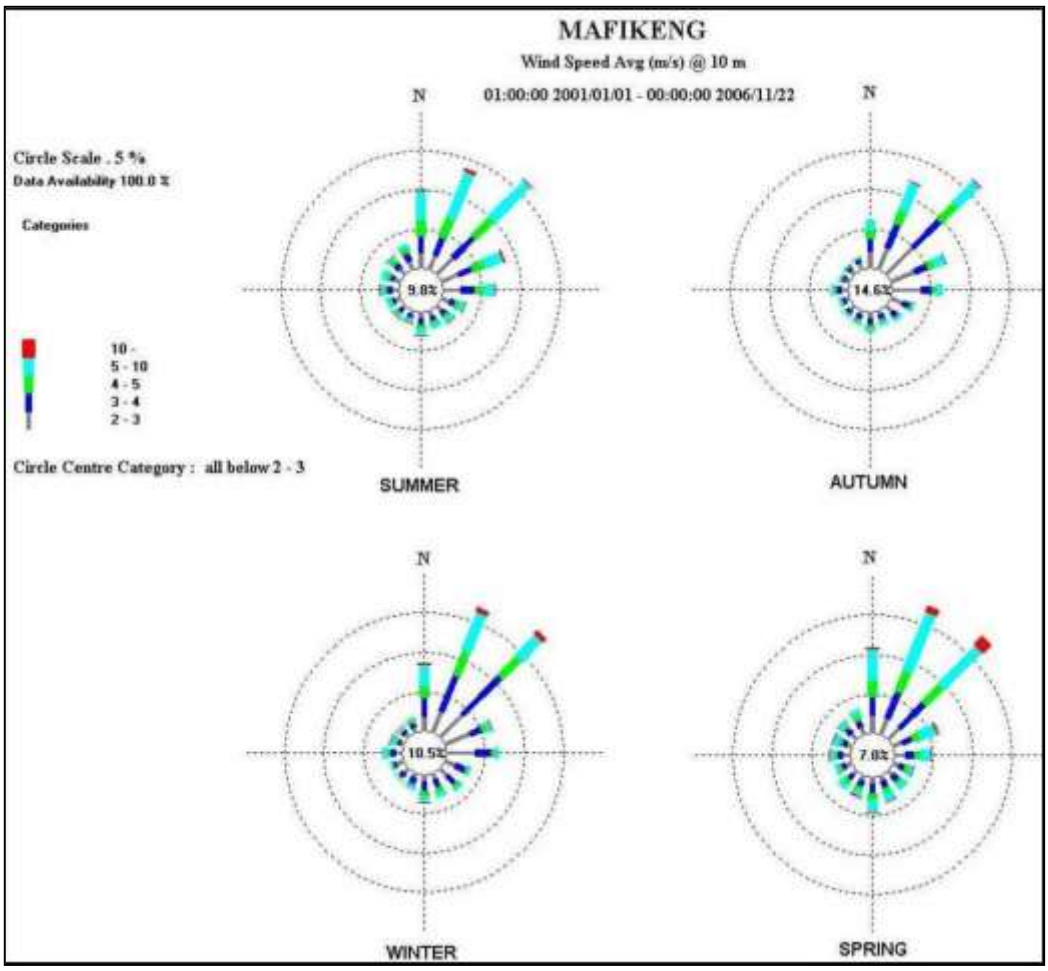


Figure 9. Wind roses for the different seasons of the project area as obtained from the Mafikeng weather station

2.3 GEOLOGY AND SOIL TYPES

Geology is directly related to soil types and plant communities that may occur in a specific area (Van Rooyen & Theron, 1996).

The area is situated close to the western termination of the Bushveld tectonic basin, consisting of the gently dipping sedimentary sequence of the Transvaal Supergroup, intruded by numerous basic sills. The main zone involved is the uppermost subdivision of the Malmani Subgroup or Frisco Formation, a 150 meter thick isolated limestone beds. The Frisco Formation is conformably overlain by banded chert of the Penge Fromation, which was strongly eroded prior to the deposition of the shale, quartzite and iron-formation of the Pretoria Group. The Malmani Subgroup is also known as the Chuniespoort Group. The soils covering the project area can be

grouped into different land types. A Landtype unit is a unique combination of soil pattern, terrain and macroclimate, the classification of which is used to determine the potential agricultural value of soils in an area. The landtypes, geology and associated soil types is presented in Table 2 below as classified by the Environmental Potential Atlas, South Africa (ENPAT, 2000). However, it must be noted that soil types are mostly determined by position on the landscape. A landtype map (figure 11) indicates the location of the landtypes in the area.

Deeper sandy soils are associated with flat topography whilst shallow, rocky soils are associated with the undulating hills and rocky outcrops. Existing agricultural activities are limited to the flat areas of the project area. As a result of the irregular undulating rocky areas, fairly steep rocky slopes, shallow rocky nature of the soils and intensity of rainfall the project area is very susceptible to water erosion, especially on roads and areas denuded of vegetation with a poor herbaceous basal cover.

Table 2. Landtype, soils and geology of the project area

Landtype	Soil	Geology
Ae59	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (no dunes)	Shale, slate, siltstone and hornfels of the Strubenkop, Silverton and Timeball Hill Formations; quartzite of the Timeball Hill and Daspoort Formations; diabase sills present. Rocks possess regional dip of 7 degrees to the north and north-east.
Ac71	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Shale, slate, siltstone and quartzite of the Rooihoogte and Timeball Hill Formations, with diabase sills in places. Dolomite and chert of the Chuniespoort Group in the south-west.

2.4 TOPOGRAPHY & DRAINAGE

The assessment of slope class in an area is an important determinant in land evaluation for crop production. Slope impacts the use of mechanical traction and together with soil textural classes, influences the rate of soil erosion. Field topography can also have a direct effect on crop growth and yield by redirecting pools of soil water. Indirectly, slope affects the distribution of certain chemical and physical properties such as organic matter content, base saturation, soil temperature, and particle size distribution (Franzmeier et al., 1969; Stone et al., 1985; Jiang, and Thelen, 2004).

The project area forms part of the Highveld and Western Bankenveld Eco-regions. The project area is located at an altitude of approximately 1 342 metres above mean sea level (m amsl). The topography is relatively flat, dipping at a low angle in a north-westerly direction. The project area is defined as hills and lowlands in the northern section, while the southern section is classified as

escarpment (ENPAT, 2000). The topography of the area is a mixture of terrains, ranging from flat to moderately undulating plains, outcrops, bottomlands (drainage channels) and slightly undulating hills.

The Water Management Areas (WMA) as defined by the Department of Water Affairs within the project area is classified as the Crocodile (West) and Marico water management area. This WMA borders on Botswana to the north-west. Its main rivers, the Crocodile and Marico, give rise to the Limpopo River at their confluence.

The Marico and Crocodile Rivers form the headwaters of the Limpopo at their confluence. The flow in the Marico River is highly variable and intermittent. There are two major storage reservoirs that regulate the flow in the Marico River, namely the Marico Bosveld Dam in the upper catchment and the Molatedi Dam further down-stream. There are several other dams, such as the Klein Maricopoort and Sehujwane Dams, from which water is mainly used for irrigation along the Marico River, particularly downstream of Marico Bosveld Dam, are present.

The Marico sub-management area corresponds to the catchment of the Marico River. Main tribuitaries of the Marico River include the Klein and Groot Marico rivers. This sub-area forms the western part of the WMA. The town of Zeerust is found in this The Groot Marico River is fed by a number of springs within the Groot Marico dolomitic aquifer compartment. These dolomitic eyes include the Molemane Eye and the Marico Eye. The upper reaches of this catchment are not densely populated.

The project area is located in the Quaternary Catchment Areas A31C and A31D . The storm water collects along roads and footpaths cutting through the area, to drain into the regionally channels indicated above. It must be noted that surface flow along these rivers generally only occurs in the period directly after precipitation events or a wet rainy season, and that these rivers may exhibit a large base-flow component with groundwater flow occurring within the sandy sediments lining its channel.

2.4.1 Vegetation types

Although the site is classified mainly as Moot Plains Bushveld, representations of the Carletonville Dolomite Grassland was also observed in the area and subsequently this vegetation type is included as part of the focus area. Figure 11 indicates the most recent vegetation map for the project area according to Sanbi (2012).

The vegetation and landscape features of the Carletonville Dolomite Grassland consist of slightly undulating plains dissected by prominent rocky chert ridges. Species-rich grasslands form a

complex mosaic pattern dominated by many species. Prominent grasses are *Loudetia simplex, Hyparrhenia hirta, Brachiaria serrata* and *Heteropogon contortus*, as well as scattered shrubs including *Euclea undulata, Searsia magalismontanum, Zanthoxylum capense* and *Diospyros lycoides*. The conservation status is "Vulnerable", with a small extent conserved. Almost a quarter of the Carletonville Dolomite Grassland Vegetation Type is already transformed for cultivation, by urban sprawl or by mining activity as well as the building of dams. Erosion is very low.

The vegetation and landscape features of the Moot Plains Bushveld consist of open to closed low, often thorny savannah dominated by various species of *Acacia* in the bottomlands as well as woodland of varying height and density on the lower hillsides. Herbaceous lyer is dominated by grasses. This vegetation functions as a transitional area between different habitats. This vegetation type has been large modified in the larger project area by agricultural activities. Moot Plains Bushveld has a vulnerable conservation status with 13% statutorily conserved and 28% transformed by means of cultivation and built-up areas.

An important aspect relating to the project area of the Doornhoek Project should be to protect and manage the biodiversity (structure and species composition) of the vegetation types represented on site. Future mining activities should aim to remove minimal vegetation and only vegetation on the footprint areas should be removed during development constructions. The unnecessary removal of tall indigenous tree species (>3m) and indigenous vegetation during construction should be avoided as far as possible.

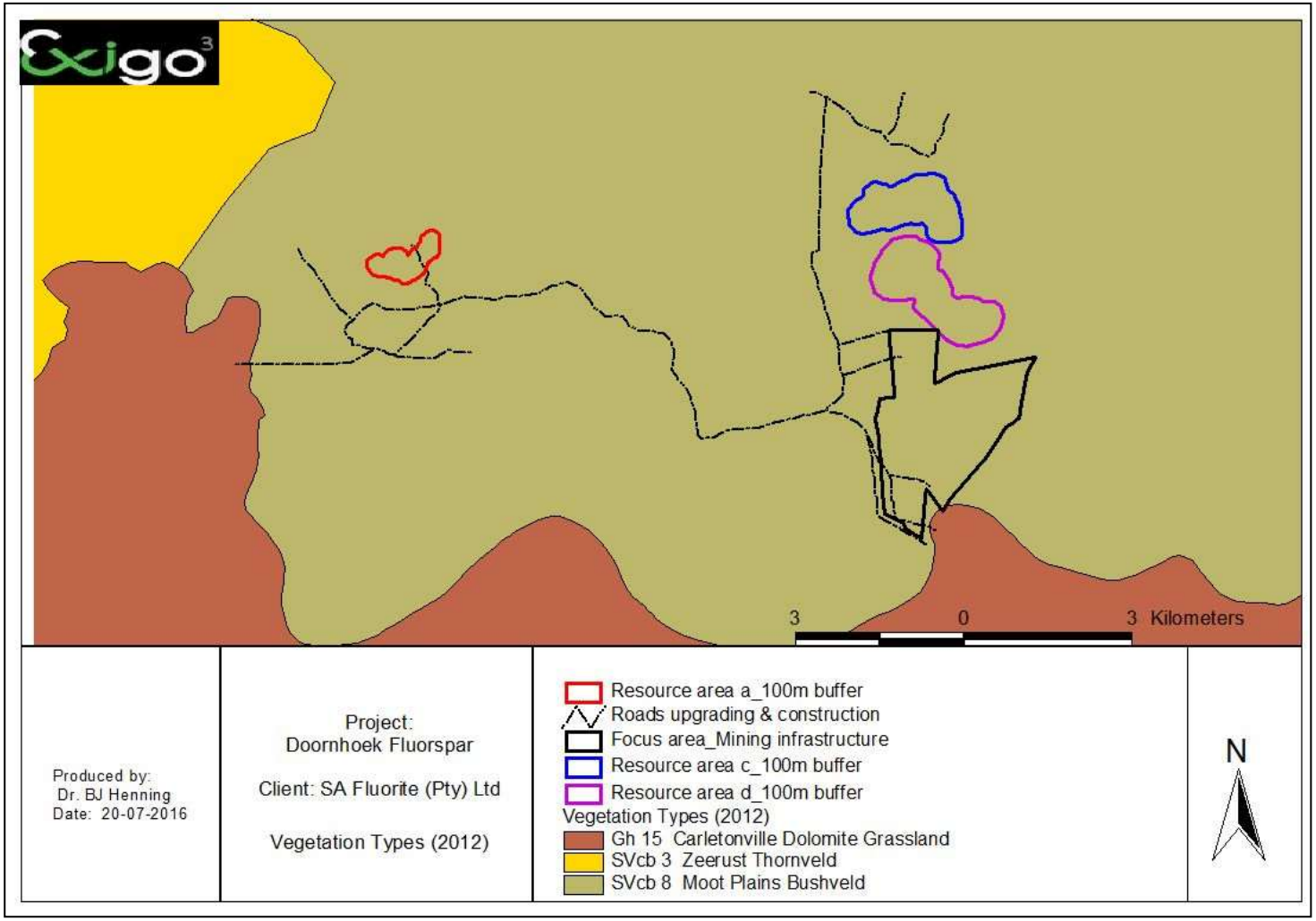


Figure 10. Vegetation Types of the project area according to the 2012 classification by Sanbi (2012)

3 GUIDELINES FOR AGRICULTURAL POTENTIAL

3.1 Moisture Availability

The moisture availability of soils is an aspect which recently has become an important factor to consider when cultivating crops under dry-land conditions. Moisture and water availability will be affected by a temperature increase, regardless of any change in rainfall. Higher temperatures increase the evaporation rate, thus reducing the level of moisture available for plant growth, although other climatic elements are involved. A warming of 1°C, with no change in precipitation, may decrease yields of wheat and maize in the core cropping regions such as the US by about 5%. A very large decrease in moisture availability in the drier regions of the world would be of great concern to the subsistence farmers that farm these lands. Reduced moisture availability would only exacerbate the existing problems of infertile soils, soil erosion and poor crop yields. In the extreme case, a reduction in moisture could lead to desertification. The classes as classified for South Africa are shown in Table 3.

Table 3. Moisture availability classes as derived from seasonal rainfall and evaporation

Moisture availability class	Summer rain season (R/0.25PET)	Winter rain season (R/0.4PET)	Agricultural Potential
1	>34	>34	Conducive to rain-fed arable agriculture
2	27-34	25-34	Conducive to rain-fed arable agriculture
3	**19-26**	**15-24**	**Conducive to rain-fed arable agriculture**
4	12-18	10-14	Marginal for rain-fed arable agriculture
5	6-12	6-9	Conditions too dry for rain-fed arable agriculture
6	<6	<6	Conditions too dry for rain-fed arable agriculture

The soils on the proposed development site are classified as class 3, which suggest that climatic conditions are conducive to rain-fed arable agriculture.

3.2 Soil classification of the site from ARC databases

The Agricultural Research Institute uses specific soil characteristics to indicate the suitability of soils for arable agriculture.

These characteristics for the site are as follows;

- Structurally favourable soils: Soils with structure favouring arable land use scarce or absent;
- Soil association:
  - Northern Section: Red, massive or weakly structured soils with high base status (association of well drained Lixisols, Cambisols, Luvisols)
  - Southern section: Red and yellow, massive or weakly structured soils with low to medium base status (association of well drained Ferralsols, Acrisols and Lixisols);

- Soil pH: 5.5-6.4;
- Prime agricultural activity for the area: Cattle

Since the classification of the soil characteristics is based on a broad-scale desktop study of the general area, a thorough investigation of the soil types of the proposed development site is necessary for a more accurate classification of the soils. The main aim of the study is to identify the soil types on site and evaluate their specific characteristics to determine the agricultural potential of the soils. The study will thus reduce the scale at which soils for the area was previously.

3.3 National assessment criteria

3.3.1 Agricultural Potential of soils in South Africa

The essence of identifying high potential agricultural land in South Africa is to retain prime area for agricultural development and to retain as much productive areas as possible for the future. South Africa is dominated by shallow soils which are predominantly sandy. This poses a severe inherent limitation to crop production. The poor quality of the soil is due to the influence of the parent material in which they were formed. According to Laker (2005), South Africa has only 13 % (approximately 14 million ha) arable land, of which only 3 % is considered to be high potential. Inferring from the international requirement of about 0.4 ha arable land to feed an individual person, South Africa could produce enough food to feed only 35 million people on the available 14 million hectares of arable land. In line with this goal, the Department of Agriculture has developed a set of criteria to define potential and prime areas for agricultural development in South Africa. By definition, based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, an agricultural land in the North West Province and specifically in the grid square in which the project site falls is considered high potential if the land:

1. Is under permanent irrigation; or
2. Can be classified into one of the following soil forms:
    a. Avalon
    b. Bainsvlei
    c. Bloemdal
    d. Clovelly
    e. Glencoe
    f. Hutton
    g. Oakleaf

h. Pinedene

i. Shortlands

j. Tukulu And

3. The effective soil depth is equal to or greater than 900mm; and

4. Topsoil clay content between 10 and 35%.

High potential here means prime or unique. Prime refers to the best available land, mainly from the national perspective, suited to and capable of consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseeds), with acceptable expenditure of energy and economic resources and minimal damage to the environment. Unique agricultural land means land that is or can be used for producing specific high value crops.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. The application may be seasonal.

The classification of the National Department of Agriculture indicate that the site lies in a quarter degree grid square (QDS) with HIGH ARABLE POTENTIAL. The soil potential classification of the Department of Agriculture is based on broad-scale mapping (QDS) and the actual field study will refine the classification based on on-site conditions. The aim of this study should therefore be to refine the classification of the site at ground level.

3.3.2 Land capability of soils in South Africa

Scotney et al. (1991) within the concept of land capability defines land capability as ―the extent to which land can meet the needs of one or more uses under defined conditions of management, without permanent damage. Land capability is an expression of the effect of physical factors (e.g. terrain form and soil type), including climate, on the total suitability and potential for use for crops that require regular tillage, for grazing, for forestry and for wildlife without damage. Land capability involves the consideration of (i) the risks of damage from erosion and other causes, (ii) the difficulties in land use caused by physical factors, including climate and (iii) the production potential‖ (Scotney et al., 1991).

The current land capability data set that is used as the national norm indicates that there are little or no soils in South Africa that are not subject to limitations. Most of the country's soils have moderate to severe limitations largely due to limited soil depth or moderate erodibility, caused by sandy texture or slopes. It was determined that nowhere in South Africa do best soil and good climate classes coincide (Schoeman et al, 2002).

The land capability classes used for the South African Agricultural Sector are indicated in Table 4, while Table 5 indicate limitations and land use potential for the Land Capability classes.

Table 4. Land capability classes (Schoeman *et al.* 2002)

Land Capability Class	Increased intensity of use									Land Capability Groups
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land
II	W	F	LG	MG	IG	LC	MC	IC	-	
III	W	F	LG	MG	IG	LC	MC	-	-	
IV	W	F	LG	MG	IG	LC	-	-	-	
V	W	-	LG	MG	-	-	-	-	-	Grazing land
VI	W	F	LG	MG	-	-	-	-	-	
VII	W	F	LG	-	-	-	-	-	-	
VIII	W	-	-	-	-	-	-	-	-	Wildlife

W - Wildlife
LG - Light grazing
IG - Intensive grazing
MC - Moderate cultivation
VIC - Very intensive cultivation
F - Forestry
MG - Moderate grazing
LC - Light cultivation
IC - Intensive cultivation

Table 5. Land capability Classes: Limitations & land use

Land Capability Class	Definition	Conservation Need	Use suitability
I	No or few limitations. Very high arable potential. Very low erosion hazard.	Good agronomic practice.	Annual cropping.
II	Slight limitations. High arable potential. Low erosion hazard.	Adequate run-off control.	Annual cropping with special tillage or ley (25%)
III	Moderate limitations. Some erosion hazards.	Special conservation practice and tillage methods.	Rotation of crops and ley (50 %).
IV	Severe limitations. Low arable potential. High erosion hazard.	Intensive conservation practice.	Long term leys (75 %)
V	Watercourse and land with wetness limitations.	Protection and control of water table.	Improved pastures or Wildlife
VI	Limitations preclude cultivation. Suitable for perennial vegetation.	Protection measures for establishment e.g. Sod-seeding	Veld and/or afforestation
VII	Very severe limitations. Suitable only for natural vegetation.	Adequate management for natural vegetation.	Natural veld grazing and afforestation
VIII	Extremely severe limitations. Not suitable for grazing or afforestation.	Total protection from agriculture.	Wildlife

From the databases of Department of Agriculture the site has the following land capability (Figure 11):

Class VI: Non-arable; Grazing, Woodland or Wildlife;

These aspects still need to be confirmed at ground level though.

Criteria for determining land capability of a piece of land are based on soil and land characteristics. These criteria related back to hazards or limitations to land use and are as follows:

- Slope %;

- Clay %;
- Effective rooting depth;
- Permeability;
- Signs of wetness;
- Rockiness;
- Soil surface crusting;

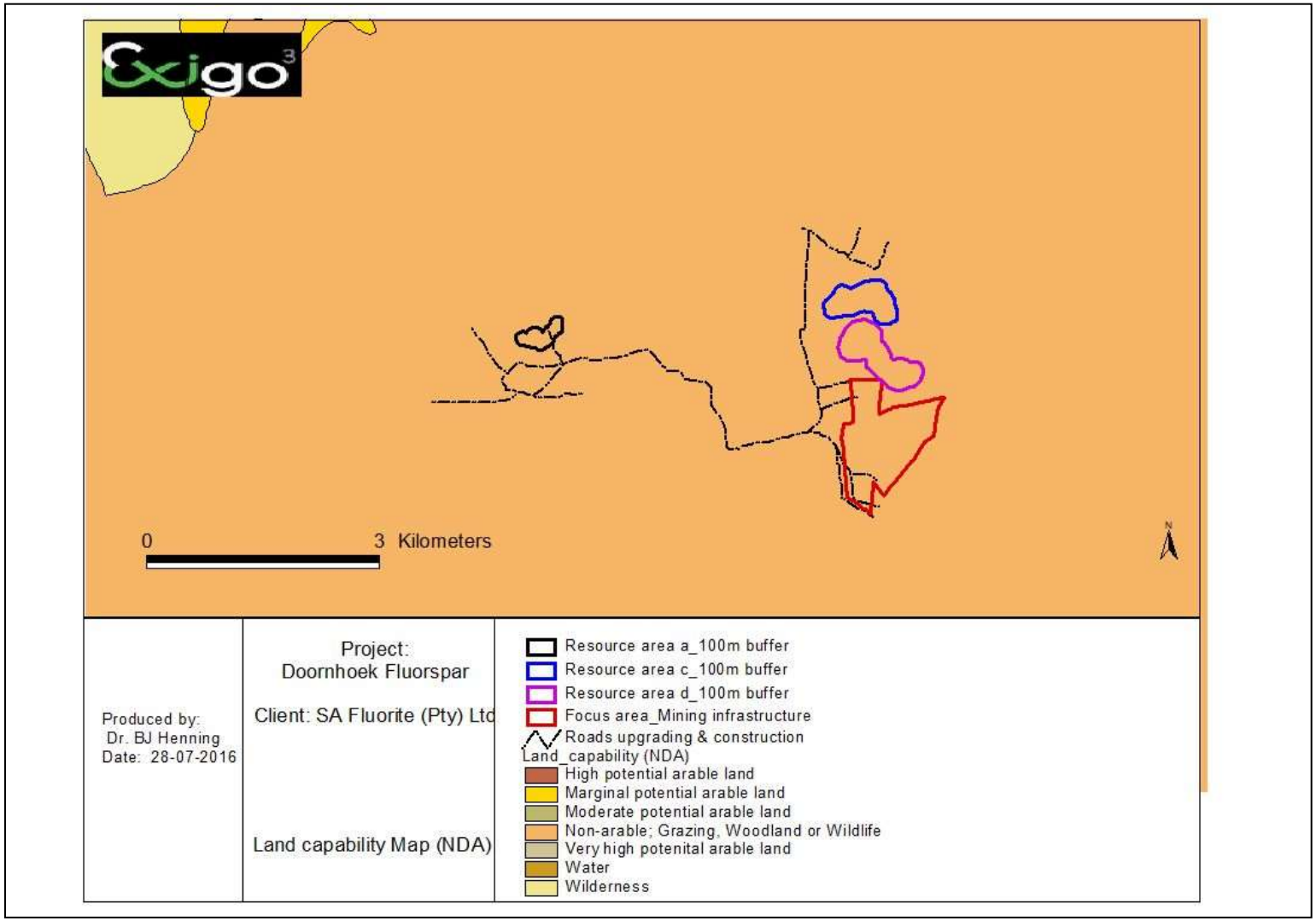


Figure 11. Land capability classes for the site as classified by the ARC: Source: [Web] http://www.agis.agric.za/agismap_atlas/AtlasViewer)

4 METHODS

The assessment of agricultural potential and land capability of the study area was based on a combination of desktop studies to amass general information and then through site visit for status quo assessment, soil sampling and characterization, and also the validation of generated information from the desktop studies:

- Definition of parameters of land as stipulated by the Subdivision of Agricultural Land Act, No. 70 of 1970 and the Amended Regulation of Conservation of Agricultural Resources Act No. 43 of 1983;
- Classification of high potential agricultural land in South Africa compiled by the Agricultural Research Council (Schoeman, 2004) for the National Department of Agriculture;
- Long-term climatic data record of the study area, obtained from Weather SA.
- Geophysical features of the site using Geographical Information System;
- Moisture availability class, determined through seasonal rainfall and fraction of the potential evapotranspiration (ARC, 2002);
- Field visit to the project site for general observation, survey of the farm in terms of vegetation, soils, water resources, terrain type and infrastructural profile;
- Previous and current land use of the farm and that of the neighbourhood;
- Other agro-ecological factors prevailing in the area;
- Agricultural potential of the property;
- Possible crop productivity or value of the farm for grazing purposes.

4.1 Soil surveys

The site surveys were conducted during June 2016. After a thorough investigation of an aerial photograph of the area and visual assessment of the specific sites and areas surrounding the sites, the following was done:

- Field observations were randomly made in the accessible, with specific emphasis on the resource area;
- Since the soils do not qualify as high potential soils according to Department of Agriculture databases, only soil physical characteristics were used to verify the potential of the soils at small-scale and therefore no chemical analyses of the soils was considered necessary;
- Slopes were analysed to determine the viability to cultivate crops in specific areas;
- The following soil physical and chemical characteristics were analysed through physical

investigation:

- Soil Depth (soil auger used);
- Soil clay content (land type memoirs);
- Soil texture and general structure.

4.2 Data recorded of surveys included:

- A description of the soil types and profiles identified on the sites;
- Specific soil characteristics on the proposed development sites and areas surrounding the sites;
- Photographs of the soil profiles and associated vegetation were taken and are included as part of the photographic guide.

4.3 Data processing

A broad classification of the soil types on the farm was done. A soil map indicates the dominant soil types identified by using a Geographic Positioning System (GPS) to locate sampled points on the topographical map of the farm. Soils were classified according to the Taxonomic Soil Classification System for South Africa, 1991. The following attributes were recorded and taken into consideration at each of the sites where samples were collected:

- Soil Type;
- Soil Depth;
- Soil clay content;
- Estimated soil texture class and soil structure;
- Slope;
- Moisture availability;
- Agricultural potential.

The agricultural potential of the soils were determined by using the specified guidelines stated above. The actual soil depth, clay content, slope, moisture potential and soil form were evaluated to determine the agricultural potential status. The soil characteristics and norms used to determine the agricultural potential of the soils were obtained from the National Department of Agriculture, which created criteria for high potential agricultural land in South Africa (Schoeman, 2004) as stated in previous discussion in the report.

5 RESULTS

The proposed development site show variation in terms of soil characteristics and soil types identified during the survey. The classification of soils on the farm was based on land type description and the Binomial System for South Africa, which classifies soils into forms and families based on the diagnostic horizon of the soil profile (Macvicar, 1991). Exposed soil profile characteristics created by road cuttings in the field were also used in describing the local soil form. In addition, a soil auger was used to assess soil depths and for sampling (if not limited by depth) at pre-determined distances during a walk-over survey on the property. Soil identification and classification of the dominant soil type were done. The soil type and profile identified on the site will be discussed in detail in the following section.

The soils were classified into broad classes according to the dominant soil form and family as follows:

- Very shallow exposed bedrock outcrops / Shallow Mispah soil form occurring throughout the study area on the undulating plains and ridges;
- Deep red apedal soils of the Hutton soil form
- Shallow, gravelly soils of the Hutton or Glenrosa soil form along the plateaus and slightly undulating terrain of the study area;
- Shallow sandyclay to sandyclayloam soils associated with seepage zones (Avalon / Longlands soil forms);
- Black clayey / alluvial soils of the Rensburg / Katspruit soil forms associated with drainage channels and valley-bottom wetlands;

The geological formations and vegetation patterns showed a strong correlation to the major soil units mapped in the study area. The location of the soil forms in the landscape is presented in figure 12, while the land capability map is indicated in figure 14.

5.1 Shallow, rocky soils of the Glenrosa or Mispah soil form associated with outcrops and ridges

Binominal Classification S.A.: Mispah / Glenrosa / bedrock soil form

Description: The soils are generally shallow and derived from dolomite or quartzite ridges in the project area. All three these soil forms can be categorised in the international classification group of lithic soil forms. In lithic soil forms the solum is dominated by rock or saprolite (weathered rock). These soils have sandy to sandyloam texture, while topsoil structure is apedal and the profiles are very shallow. Exposed rocks and boulders is spread on the soil surface throughout the area.

The soil in this area is often weakly structured, sandy to loamy and forms a mosaic of shallow Glenrosa soils and very shallow rocky soils (Mispah soil form), with the outrops mostly consisting of bedrock. The Mispah and Glenrosa soils found on this section of the site are widespread and shallow in depth, although it has a medium clay content.

Landscape: Rocky ridges / undulating slopes (Photograph 1)

Depth: 50-200mm

Texture: Sandy to sandy loam soils

Average Clay Content: 8-15%

Agricultural Potential: Low potential soils, due to the shallow nature of the soils and sloping terrain, making these areas are not suitable for crop cultivation under arable conditions. The orthic A-horizon of the lithic soil group is unsuitable for annual cropping or forage plants (poor rooting medium since the low total available moisture causes the soil to be drought prone). These topsoils are not ideal for rehabilitation purposes for they are too shallow and/or too rocky to strip. Topsoil stripping and stockpiling of the "shallow" soils should only be attempted where the surface is not too rocky.

Land capability: The grazing potential of these areas is moderate-low. The most suitable and optimal utilization of the area would be grazing by small livestock or game species.

Photograph 1. Shallow soils associated with outcrops in the project area

5.2 Deep red apedal soils of the Hutton soil form

Binominal Classification S.A.: Hutton soil form;

Description: Hutton soils are identified on the basis of the presence of an apedal (structureless) "red" B-horizon as indicated in Photograph 2. These soils are the main agricultural soil found in South Africa, due to the deep, well-drained nature of these soils. The Hutton soils found on the site are restricted to the low-lying valleys and plains of the project area. The Hutton soil form on site is deep, although it has a moderate low clay content. The relatively high magnesium and iron content of the parent rocks

from which these soils are derived, impart the strong red colours noted.

Landscape: Slightly undulating plains (Photograph 3)

Depth: 600-1200mm;

Texture: Sandyloam;

Average Clay Content: 10-20%;

Agricultural Potential: Moderate potential soils– soils deep and often sandyloam structure that causes a medium water holding capacity, although the clay content of the soils is sufficient. However, under the climatic conditions these soils would not sustain arable crop production. The most viable option for crop production on the soil form is under irrigation considering the variable rainfall and moisture availability due to higher day temperatures. Irrigation is not a common practice in the study area though and for any irrigation to be undertaken in the area, it will require the installation of a number of surface water impoundments as storage during the dry months. The limited water availability, high evaporation rates and high water demands by crops would therefore render crop cultivation not sustainable in the study area. The many old cultivated fields confirm that crop cultivation over the longer term is not a financially viable option under the prevailing climatic conditions.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in woodland areas that support a mixture of palatable and unpalatable species.

Photograph 2. Typical soil profile of the Hutton soil form in the project area

Photograph 3. Typical landscape and road cutting associated with the deep Hutton soils

5.3 Shallow / medium depth red-yellow apedal soils of the Glenrosa / Hutton Soil Forms

Binominal Classification S.A.: Hutton soil form; Glenrosa soil form

Description: The Hutton soils found on the site occur in pockets throughout the study area on plateaus and slightly undulating plains. The shallow Hutton soil forms are especially dominant in the southern and western section of the study area where the underlying bedrock is dolomite or chert. The Hutton soil form on site varies from shallow to deeper and has a medium to high clay content. The relatively high magnesium and iron content of the parent rocks from which these soils are derived, impart the strong red colours noted. Where it becomes very shallow the soil are classified as Glenrosa soil form.

Landscape: Plains / Plateaus (Photograph 4)

Depth of soil forms: 100-400 (Glenrosa, Hutton, Photograph 5)

Texture: Sandyloam

Vegetation: Pristine grassland / woodland associated with plateaus / undulating plains

Average Clay Content: 10-15% (Hutton); 6-15 (Glenrosa)

Agricultural Potential: Moderate potential soils depending on soil depth and size of land available for sustainable arable agriculture. Soils vary from shallow and sandy in some areas (Glenrosa, Hutton soil form) to deeper with a higher clay content (Hutton soil form). The red apedal Hutton soils with a higher clay content in the topsoil has a high water holding capacity. Under the climatic conditions these soils would sustain arable crop production, although as isolated pockets that cannot be

considered economically viable units. The areas with deeper soils represent the most viable options for crop production under arable conditions considering the rainfall and moisture availability in the topsoil. Considering that the amount of land that is needed to economically sustain arable agriculture, the soil type described above cannot be considered as viable for crop production. The many old cultivated fields confirm that crop cultivation over the longer term is not a financially viable option under the prevailing climatic conditions.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in grassland areas that support a mixture of palatable and unpalatable species.

Photograph 4. Shallow Hutton / Glenrosa soil forms in the southern section of the project area

Photograph 5. Profile of the shallow Hutton soil in the project area

5.4 Shallow sandyclay to sandyclayloam soils associated with seepage zones (Avalon / Longlands soil forms)

Binominal Classification S.A.: Avalon soil form (dominant); Wasbank / Longlands (isolated pockets)

Description: The Avalon soil form is characterised by the occurrence of a yellow-brown apedal B-horizon over a soft plinthic B – horizon (Photograph 6). The yellow-brown apedal horizon has the following characteristics:

- Has undergone localised accumulation of iron and manganese oxides under conditions of a fluctuating water table with clear red-brown, yellow-brown or black strains in more than 10%of the horizon;
- Has grey colours of gleying in or directly underneath the horizon; and
- Does not qualify as a diagnostic soft carbonate horizon.
- These soils are found between lower down the slopes than the Clovelly soils and indicate the start of the soils with clay accumulation.

Landscape: Hillslope seepage and valleyhead seep wetlands along slopes (Photograph 7)

Depth: 800-1200mm;

Texture: Sandyclay to sandyclayloam;

Average Clay Content: 5-10%;

Agricultural Potential: The Avalon soil form has a medium-low clay content and the low water holding capacity of these seasonally wet seep wetlands would limit crop cultivation. The area therefore has a Low Potential for crop cultivation. The production system is extremely management sensitive.

Land capability: These soils support mixed quality grazing and can be utilized as high quality livestock grazing throughout the year, especially as planted pastures. The area therefore has a moderate to high potential for livestock grazing. The only limiting factor may be that livestock movement is limited during the wet season when the clay expands, causing livestock to get stuck in the muddy conditions. Soils are very sensitive and prone to erosion.

Photograph 6. Soil profile associated with the Avalon Soil Form in the project area at a seep wetland

Photograph 7. Landscape associated with seeps in the project area

5.5 Black or dark grey clayey Soils associated with the drainage channels and floodplains of the Oakleaf, Cartref and Valsrivier soil forms

Binominal Classification S.A.: Oakleaf, Cartref and Valsrivier soil forms

Description: The soils are generally dark grey to black in the topsoil horizons, and high in transported clays, and show pronounced mottling on gleyed backgrounds in the subsoils. These soils occur within

the zone of groundwater influence. The soils are alluvial and are deep (>1,2m) with an orthic A and neocutanic B with signs of wetness in the horisons. Brown A horizon and red-brown B horizon. The soils are slightly sensitive to erosion. The subsoil is more sensitive to erosion and should preferably not be exposed.

Landscape: Bottomlands (drainage channel and floodplains) (Photograph 9, 10)

Depth: >1200mm

Texture: Sandyclay to Sandyclayloam

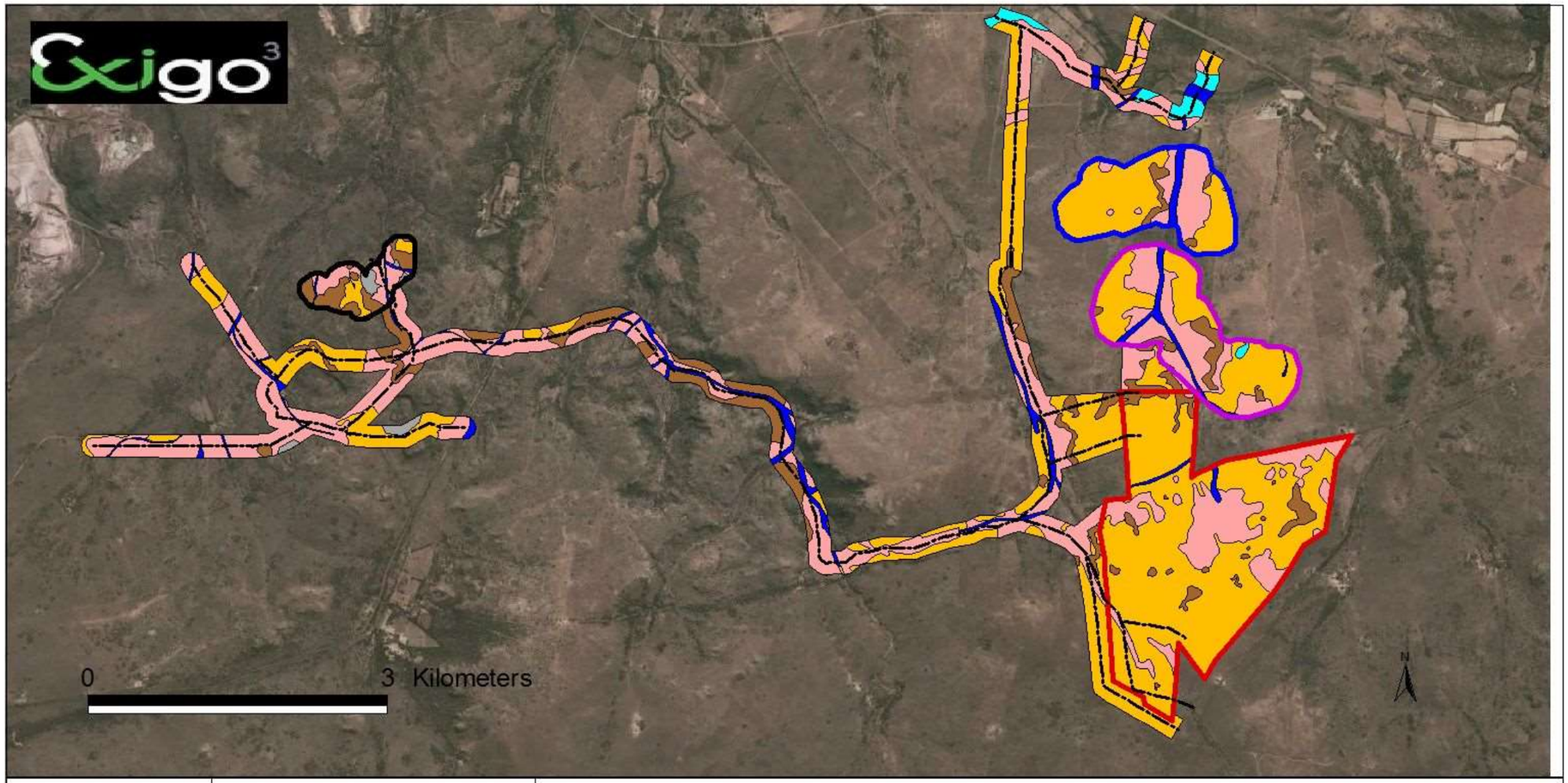
Average Clay Content: 10-30%

Agricultural Potential: Zero potential soils, due to the soil wetness these areas are not suitable for crop cultivation under arable conditions.

Land capability: The grazing potential of these low-lying areas is high due to the palatable grasses growing throughout the year on these soils. The only limiting factor may be that livestock movement is limited during the wet season when the clay expands, causing livestock to get stuck in the muddy conditions. Soils are very sensitive and prone to erosion. A specific strategy is needed to prevent damage to these soils considering that overgrazing and trampling has already caused some degradation of the floodplains.

Photograph 8. Floodplains and riparian woodland adjacent to the Klein Marico River in the project area

Photograph 9. Non-perennial water courses in the project area



Produced by:
Dr. BJ Henning
Date: 28-07-2016

Project:
Doornhoek Fluorspar

Client: SA Fluorite (Pty) Ltd

Soil Forms

Resource area a_100m buffer
Resource area d_100m buffer
Resource area c_100m buffer
Roads upgrading & construction
Focus area_Mining infrastructure

Soil forms
Red apedal Hutton soils (Valleys / plains)
Shallow / medium depth red-yellow apedal soils of the Glenrosa / Hutton Soil Forms
Shallow sandyclay to sandyclayloam soils associated with seepage zones (Avalon / Longlands soil forms)
Shallow, rocky soils of the Glenrosa or Mispah soil form associated with outcrops and ridges
Soils associated with the drainage channels and floodplains of the Oakleaf, Cartref and Valsrivier soil forms
Topsoil disturbed - old mining quarries

Figure 12. Soil form map of the project area

6 AGRO-ENTERPRISE AND LAND CAPABILITY

Land capability is a system that was developed by the U.S. Department of Agriculture in the 1950s. It separates soils into classes of increasing land use limitations. Criteria used in the original system related only to soil physical properties and not soil fertility. If land capability is to be utilised in the agricultural sector, soil fertility parameters alongside yield data need to be taken into account. Increasingly this has been the case with the development of soil potential mapping.

6.1 Climatic conditions

The area is expected to receive an annual total rainfall between 400 and 500mm, of which most fall from October to April. This amount is considered LOW and unsuitable for crop cultivation under arable conditions. The high variability in rainfall distribution within the area could however render dry land farming a risky venture, even under irrigated conditions considering the sandy nature of the soils which has a low water holding capacity.

The project site is thus dry which would contribute to moisture stress condition during crop growth and development. The potential of groundwater is relatively low to sustain a high water demanding irrigated cropping, expected at the project site.

6.2 Crop production

The soils of the project site vary from being shallow and rocky in the ridges to sandy on the surrounding plains, with isolated areas where deeper, more fertile soils occur associated with the western and southern areas of the project site and pockets of moist grassland on sandy-clay soils. The grazing capacity map of the Department of Agriculture for the study area is presented in Figure 13.

The typical landscape of the project site is dominated by shallow, rocky soils associated with rocky ridges or very sandy / gravelly soils associated with plateaus, ridges and footslopes. These soils have a low clay content and water holding capacity, and in combination with the climatic conditions render this section of the proposed development site unfavourable for effective crop production which could result from high moisture demands by planted crops.

The isolated pockets of moist grassland and ravines have shallow sandy-clay or clay soils that are seasonally flooded or have a perched water table. These areas are unsuitable for crop cultivation.

The climatic conditions in combination with the shallow nature of the soils render the study area unfavourable for effective crop production which could result from high moisture demands by planted crops. The study area is also expected to receive an annual total rainfall of about 450 mm which is relatively low and highly variable. In addition, the farm is considered to be located in an area which is marginal for rain-fed arable crop production. Economically viable farming is thus restrictive to irrigated

cropping due the high risk that could be associated with dry-land farming. Higher day temperatures in summer months may hamper soil moisture storage for crop use. At present no irrigation or functional centre pivots occur on the property.

6.3 Livestock production / wildlife grazing

The natural vegetation in the study area has a grazing capacity that varies from low (shallow, rocky or sandy soils) to medium (seasonally wet soils, deeper loamy soils). The different sections of the study area can support grazing according to the soil nutrient content as follows:

- The shallow, rocky soils associated with the slopes of outcrops has low quality grazing and at present game species utilize these areas, especially during the early summer months (September to December) when the grasses resprout in burned areas.
- The deep sandy and gravelly soils associated with the footslopes, valley floors and plateaus has low quality grazing with limited potential for livestock farming. These areas are however suitable grazing for specialized grazers such as sable antelope.
- The red-yellow apedal soils associated with the study area has a medium potential for livestock grazing due to the slightly higher nutrient content of the soil supporting a mixture of palatable and unpalatable grasses. Grazing value decreases as the season changes from summer to winter though, with the lowest grazing potential available to livestock at the end of the season.
- The seasonally wet soils of the study area support palatable grass species and these areas have a medium to high suitability for livestock or game grazing. These soils have a good water holding capacity and grass species that grow in these areas vary from having a medium to high palatability depending on the seasonal changes.

The land capability classes for the study area are indicated in Figure 14.

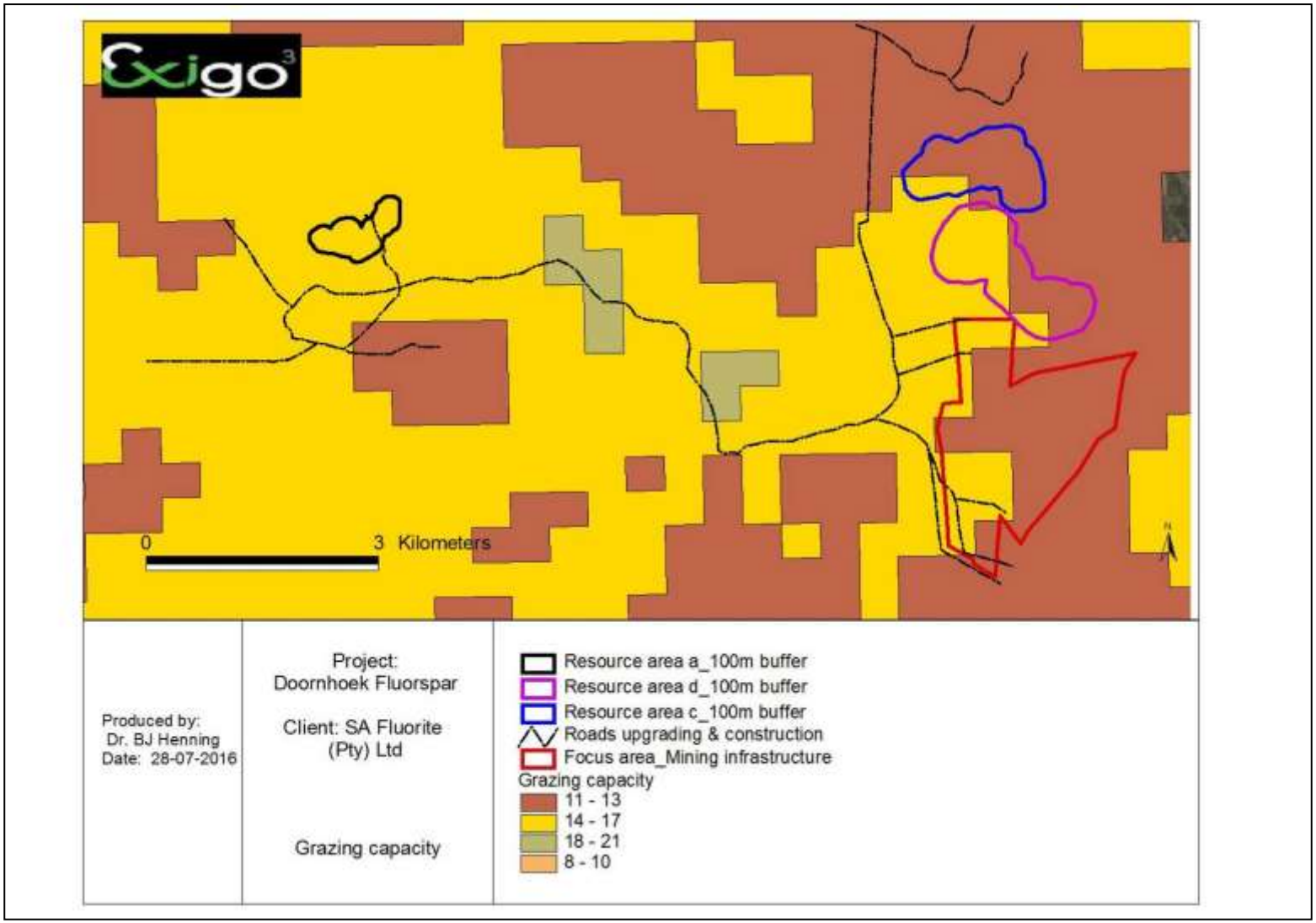
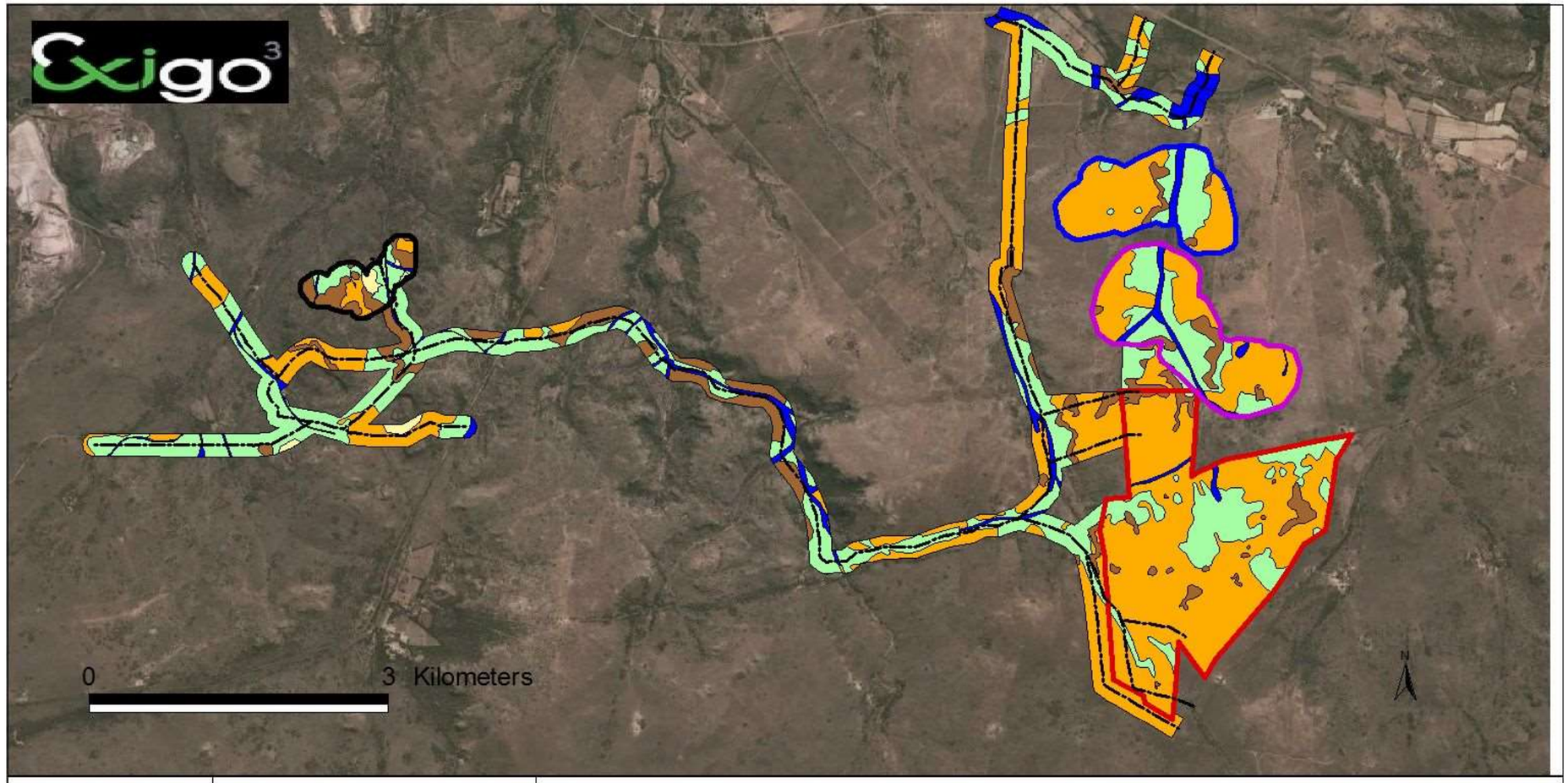


Figure 13. Grazing capacity map of the study area 1993 database Source: [Web] http://www.agis.agric.za/agismap_atlas/AtlasViewer)



Produced by:
Dr. BJ Henning
Date: 28-07-2016

Project:
Doornhoek Fluorspar

Client: SA Fluorite (Pty) Ltd

Land capability

Resource area a_100m buffer
Resource area d_100m buffer
Resource area c_100m buffer
Roads upgrading & construction
Focus area_Mining infrastructure
Land capability
Class IV: Severe limitations. Low arable potential. High erosion hazard.
Class V: Watercourse and land with wetness limitations
Class VI: Limitations preclude cultivation. Suitable for perennial vegetation.
Class VII: Very severe limitations. Suitable only for natural vegetation
Topsoil disturbed - No Class applicable

Figure 14. Land capability map for the proposed Fluorspar Mine development

7 ANTICIPATED SOIL IMPACTS

The objective of this section was to identify impacts and provide a list of actions and potential impacts associated with the various mining phases namely the planning and design phase, construction phase, operational phase, decommission phase and closure phase for the various mining components:

- Opencast Mining;
- Processing Plant and TSF;
- Support infrastructure including roads, workshops (but excluding portal areas and surface area).

The impacts associated with the mining development on the soils and land capability will depend on the specific area where the mining activities will take place. Any mining activities on the shallow rocky soils (throughout most parts of the site) on plains and plateaus will have a low impact on the soil potential or land capability, with only marginal erosion risks that can be managed though proper mitigation measures. The mining activities that will take place along the flatter terrain associated with the valley floors and plains where deeper, clayey soils occur will not have any negative impact on crop production and local food security as a result of the seasonally wet conditions, and any potential impacts (compaction, erosion) on these low-lying areas will be easier to mitigate. The section below described the impacts associated with the mining development on the soils and land capability in more detail.

7.1 PLANNING AND DESIGN PHASE

Planning and design is necessary to ensure that mitigation and impact management can be effectively implemented and minimise impacts in future. The planning and design phase of the mine will involve the following actions:

- Layout avoidance of sensitive soil types associated with steep slopes, floodplains, soils with high erosion / compaction risk ;

No specific direct impacts will occur on the soils of the area during this phase.

7.2 Construction Phase

The development and start-up of the mining operation covers the period of time when considerable changes take place as the mine infrastructure, plant and facilities are constructed, and when the ore body is first exposed. The most immediate impacts are seen as disruptions and disturbances to soil include stripping of topsoil and exposure of soils sue to site clearance for construction of the plant, tailings facility, access and haul roads and other mining related infrastructure. This is usually a significant change to the visual appeal of the area.

Exposure of rocks, ore and soils to rainfall and wind may lead to atmospheric contamination by dusts and increased erosion of the site and sedimentation of local water courses. An increase in the movement of construction vehicles will result in an increase in the dust levels in the area. The

following impacts will occur during the construction phase of the mine:

- **Soil compaction** occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. In addition, the exchange of gases slows down in compacted soils, causing an increase in the likelihood of aeration-related problems. Finally, while soil compaction increases soil strength-the ability of soil to resist being moved by an applied force-a compacted soil also means that roots must exert greater force to penetrate the compacted layer. In the case of mining activities associated with the proposed fluorspar mine during construction, soil compaction will be caused by regular heavy vehicle movement (wheel impact) and laydown areas of stockpiles on soils. If mitigating measures are not implemented the effect of the compaction will negatively affect soil structure of soils on the site.
- **Soil erosion and sedimentation**: Mining activities may further result in widespread soil disturbance and is usually associated with accelerated **soil erosion**, particularly in the study area during the summer months that receives high rainfall. Soil is especially prone to erosion once the topsoil have been stripped, leaving the soil exposed to wind and water erosion. Any soils left exposed throughout the construction phase could lead to significant erosion of the soils in the vicinity of the mining development. Soil, sediments and associated contaminants are transported into streams, rivers and other water bodies, resulting in the loss or alteration of habitats for aquatic organisms, as well as changes in water quality. The hardened surfaces and compacted soils of the development area will also lead to an increase in surface run-off during storm events which will likely be discharged via stormwater outlet points, concentrating flows leaving the development area. Soil erosion also promotes a variety of terrestrial ecological changes associated with disturbed areas, including the establishment of alien invasive plant species, altered plant community species composition and loss of habitat for indigenous fauna and flora.
- **Soil pollution:** Construction work of the magnitude contemplated for the proposed mine will always carry a substantial risk of soil pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. Building waste, batching plants, sewage and domestic waste are also potential contributors to this problem. If not promptly dealt with, spillages or accumulation of waste matter can contaminate the soil and surface or ground water, leading to potential medium/long-term impacts on soil chemical composition.
- **Soil destruction** is a form of soil degradation that involves the total destruction of natural soil bodies and all the parameters that led to the formation of the soil. Stripping of the topsoil during construction will remove the fertile layer of the soil. This will result in the loss of the soil carbon content as well as soil micro-organisms that support the soil nutrient cycles.

- **Loss of land capability:** This impact involves the loss of land available for farming and tourism: The area where the mine is proposed is located in an area used for game farming and livestock grazing, although some mining activities also occur in the broader area. The land in general has a low to almost zero capability for crop cultivation and can mostly be utilized as grazing for wildlife. The construction of the proposed mine will result in a total loss of the land capability as it currently is and will change the current land use from grazing to industrial land-use. The mining operations will have a negative impact initially and will reduce the percentage of land available for livestock grazing and agricultural activities done. The surface area of the mine to be disturbed is however relatively small and therefore the impact will not be as significant as anticipated.

7.3 Operational Phase

The routine operational phases account for most of the environmental impacts associated with mining and are considered to have the greatest potential to drive environmental change. The extent to which mining operational activities act as drivers of environmental change depends in part on the type, scale, duration and magnitude of the activities, and the sensitivity of the receiving environment.

The removal and storage (stockpiling) of ore in the operational phase is usually the most intensive activity on any mine operation. The process involves exposure of ore bodies, followed by loading and transportation of the ore to the stockpile sites. These activities are characterized by large-scale disturbance due to noise and generation of dust from the movement of vehicles and possible wind-blown dust from stockpiles at the recovery plant.

Typical activities of the operational phase will include:

- Opencast mining of ore body;
- Processing of ore in the processing plant;
- Storage of tailings (revised TSF height is approx. 40 m.)
- Disposal of overburden on overburden dumps;
- Transporting of people and equipment;
- Transportation of product off-site;
- Transportation of supplies to the site;
- Handling and storage of hazardous materials and substances;
- Domestic waste generation, storage and disposal;
  - Water storage facilities;
  - Hazardous waste storage and disposal;

A short description of the impacts associated with the operational phase is included below:

- In the case of mining activities associated with the proposed fluorspar mine during operation, soil compaction will be caused by regular heavy vehicle movement (wheel impact)

and laydown areas of stockpiles and overburden dumps on soils.

- The hardened surfaces and compacted soils of the mining development area will also lead to an increase in surface run-off during storm events which will likely be discharged via stormwater outlet points, concentrating flows leaving the mining area. This can lead to erosion and channel incision in the water courses and change the in-stream habitat. This could result in higher velocity flows with greater erosive energy which can result in channel incision and gully erosion downstream within the channel and floodplain wetlands. The bare side slopes of the soil stockpiles and steep slopes associated with soil stockpiles will result in erosion of the stockpiles and movement of the eroded sediment into the wetland areas to the drainage channel that eventually feed the Pienaars River to the east of the site leading to increased sedimentation within the wetlands and possible changes to flow and vegetation. The sediment is likely to deposit out where gradients flatten, generally sites of wetlands.
- During the operational phase heavy machinery and vehicles as well as sewage and domestic waste would be the main contributors to potential soil pollution problems.
- In the case of the Doornhoek Fluorspar Mine the activity that will lead to soil destruction during the operational phase is opencast mining. The opencast mining activities will disturb the soil profile, the topographical and profile sequence of soils and the geohydrology of the landscape (determines the types and position of soil horizons and soil forms and that removes all original vegetation cover and animals from the specific soils). The effect is a combination of drastic physical, chemical and biological degradation of the soils on the mining site with the resultant alteration in soil quality. The effect of topsoil stripping during the construction phase of the mine will have a long term effect that would stretch into the operational phase of the project and will ultimately lead to the irretrievable commitment of this resource. The measurable effect of the construction and operational phase on this resource and the likeliness of preventing or reducing the effect by utilizing mitigation measures are negligible. The reason for this is that most of the organic carbon as well as the soil microbial life, are contained in the topsoil horizon. These components are crucial for the maintenance of the vegetation layer. Once the surface horizon is removed during construction and stockpiled, the nutrient cycles such as the carbon and nitrogen cycles are disturbed and the organic matter breaks down very quickly. Although the topsoil may later be replaced in more or less the original position in the landscape, the soil fertility will have been compromised. Therefore the significance of the potential impact after mitigation is still considered to be high.
- The operation of the proposed mine will result in a total loss of the land capability as it currently is and will change the current land use from grazing to industrial land-use. The mining operations will have a negative impact initially and will reduce the percentage of land

available for livestock grazing and agricultural activities done, but will partially recover after successful rehabilitation provides good grazing. The mining activities that will reduce the land capability during the operational phase of the mine include the dumping of overburden, opencast mining and laydown of stockpiles.

7.4 Decommissioning and Closure Phases

The decommissioning phase starts when all the economically exploitable mineral reserves in an area have been extracted. The actions which mark this phase include:

- Cessation of mining;
- Removal of mine infrastructure
- Backfilling of the mined out areas.

The closure phases of the mine involve rehabilitation actions to mitigate impacts caused during the construction and operational phase of the mine. Some of the rehabilitation actions include the following:

- Ripping and rehabilitation of all haul roads;
- Rehabilitation of the opencast areas and TSF;
- Seeding of ripped and rehabilitated surfaces;

The major impacts on the soils during these phases are as follows:

- Soil compaction is likely to occur over much of the rehabilitated opencast area as a consequence of the storage and placement of soil and the change in structure following placement. In the case of mining activities associated with the proposed fluorspar mine during the closure phase, it will be reduced as a result of rehabilitation activities, although compaction will still be caused by regular heavy vehicle movement during rehabilitation.

- The poor soil cover associated with rehabilitated opencast areas also renders the site more susceptible to erosion and soil loss. It is probable that these soils will be transferred through the rehabilitated landscape into the draining water courses and receiving water bodies as described earlier. The rehabilitation of the site and decreased surfaces will however still reduce the risk of erosion and sedimentation carried into the wetlands and rivers during the closure phase, compared to the other phases. Soil compaction is likely to occur over much of the rehabilitated area as a consequence of the storage and placement of soil and the change in structure following placement. The poor soil cover associated with rehabilitated opencast areas also renders the site more susceptible to erosion and soil loss. It is probable that these soils will be transferred through the rehabilitated landscape into the draining water courses and receiving water bodies as described earlier.

- During the closure phase of the mine the risk of spillages are still pertinent, although the impact will mainly be limited to potential spillages from vehicles. The impact will therefore be greatly reduced as a result of concurrent rehabilitation and removal of potential spillage sources (sewage plant, heavy machinery).
- Although the cleared areas and the opencast areas will eventually be revegated, it is not anticipated that grazing areas that was lost to mining will be remediated to such an extent that the land capability will return.

8 QUANTITATIVE IMPACT ASSESSMENT

Table 6 indicate the impacts described above and specific ratings of significance the impact will potentially have on the ecosystem during the proposed mining activities according to the layout plan of the mining development:

Table 6. Quantitative impact assessment for the various mining components and mining phases on the soils and land capability

No	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
Planning Phase																
1	Delay of mining onset	Obtaining of IWUL for crossings (wetland soils) and mining layout on sensitive soils	**WOM**	**Negative**	Definite	5	Short term	1	Local	1	High	8	50	Moderate	Apply and obtain IWUL from DWS after liaison with relevant officials and site visit to the area	Can be avoided, managed or mitigated
			WM	**Negative**	Highly Probable	4	Short term	1	Local	1	Medium	6	32	Low		Can be reversed
Construction Phase																
2	Soil compaction	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Permanent	5	Local	1	High	8	70	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
3	Soil erosion and sedimentation	Topsoil & subsoil stripping, exposure of soils, ore and rock to wind and rain during construction causing erosion and sedimentation in wetlands	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be avoided, managed or mitigated
4	Spillages of harmful substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Long term	4	Site	2	Low	2	16	Negligible		Can be reversed
5	Soil destruction and sterlization	Topsoil & subsoil stripping, opencast mining	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	High	8	65	High		Can be reversed
6	Loss of land capability	Topsoil & subsoil stripping, Clearing of vegetation for openpit through wetlands and water courses as well as road crossings	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed
Operational Phase																
7	Soil compaction	Heavy machinery and vehicle movement on site, laydown areas of overburden dumps and stockpiles	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Site	2	High	8	70	High		Can be avoided, managed or mitigated
8	Soil erosion and sedimentation in wetland / water courses	Increased hardened surfaces around infrastructure and exposed areas around openpits, laydown areas of overburden dumps and stockpiles as well as TSF, road crossings	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate		Can be avoided, managed or mitigated
9	Spillages of harmful substances leading to water pollution in wetlands	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be reversed
10	Soil destruction and sterlization	Topsoil & subsoil stripping, opencast mining	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Medium	6	55	Moderate		Can be reversed

No	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
11	Loss of land capability	Topsoil & subsoil stripping, Clearing of vegetation for openpit through wetlands and water courses as well as road crossings	WOM	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed
Closure and Decommissioning Phase																
12	Improvement of eroded soils and compaction / backfilling of pits	Rehabilitation of mining site	WOM	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 9 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
13	Soil erosion and sedimentation	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site	WOM	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be avoided, managed or mitigated
14	Soil compaction	Heavy machinery and vehicle movement on site	WOM	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
15	Spillages of harmful substances	Heavy machinery and vehicle movement on site	WOM	Negative	Highly Probable	4	Medium term	3	Regional	3	Medium	6	48	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Site	2	Low	2	10	Negligible		Can be avoided, managed or mitigated
Post-Closure Phase																
16	Improvement of land capability	Natural processes	WOM	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 9 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
17	Soil erosion and sedimentation	Exposed surfaces / unrehabilitated areas on site post closure / poor monitoring during LoM	WOM	Negative	Highly Probable	4	Medium term	3	Site	2	Medium	6	44	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Local	1	Low	2	8	Negligible		Can be avoided, managed or mitigated

9 SOILS AND LAND CAPABILITY MANAGEMENT PLAN AND MITIGATION MEASURES FOR THE PROPOSED DOORNHOEK FLUORSPAR MINE

A management system has been developed to comply with the objectives and principles set out in this document. This system is based on the principle of managing the potential environmental impacts using the best available technology, not entailing excessive cost. In this way, the technology is effective, but does not seriously impair economic stability of the development. Management measures required for the different phases of the mine which relates to biodiversity is presented in Table 17 below.

Table 7. Soils and Land Capability Management Plan to be implemented as part of the Environmental Management Programme Report for the Doornhoek Fluorspar Mine

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
Planning and Design phase									
Pre-mining	Mining through sensitive soils and road crossings across wetlands / water courses	Soils	Delay of mining onset	National Water Act Section 21 C and I	Obtaining of IWUL for crossings and mining through water courses / wetlands	Application forms completed as obtained from DWS	Apply and obtain IWUL from DWS after liaison with relevant officials and site visit to the area	2 years	Environmental Assessment Practitioner (EAP)
Construction Phase									
OC Mining, Support infrastructure, TSF and Plant	Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans • To limit soil loss and compaction	Keep mining development footprint restricted to layout plans	• Soil should be handled when dry during removal and placement to reduce the risk of compaction; • Vegetation (grass and small shrubs) should not be cleared from the site prior to mining activities or construction (except if vegetation requires relocation as determined through an ecology assessment). This material is to be stripped together with topsoil as it will supplement the organic and possibly seed content of the topsoil stockpile depending on the time of soil stripping (whether plants are in seed or not); and • During construction, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by construction vehicles and equipment, wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment.	Continuous	Contractor / ECO
OC Mining, Support infrastructure, TSF and Plant	Topsoil & subsoil stripping	Soils	Soil erosion and sedimentation	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• To prevent the loss of soil through the expansion of the overburden dumps • To prevent the loss of topsoil capability during stockpiling • To prevent the contamination of soils due to spillages of reagents • To prevent soil erosion	Management of storm water on site; Minimize time that soil is left exposed after vegetation is cleared that will cause erosion and sedimentation	• When possible, topsoil stripping and excavation activities should be scheduled for the low rainfall season (winter); • Cover disturbed soils as completely as possible, using vegetation or other materials; • Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices. • Sediment trapping, erosion and storm water control should be addressed by a hydrological engineer in a detailed storm water management plan; • All aspects related to dust and air quality should be addressed by an air quality specialist in a specialist report; • Protect sloping areas and drainage channel banks that are susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and Work Areas; • Repair all erosion damage as soon as possible to allow for sufficient rehabilitation growth; • Gravel roads must be well drained in order to limit soil erosion;	Continuous	Contractor / ECO
OC Mining, Support infrastructure, TSF and Plant	Heavy machinery & vehicle movement on site	Soils	Spillages	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	• To prevent contamination of soil due to the spillages of hydrocarbons and reagents used in the process and during transportation of these substances	Active monitoring of potential spillages	• Ensure that mining related waste or spillage and effluent do not affect the sensitive habitat boundaries and associated buffer zones. • This risk of spillages of reagents and hydrocarbons on the soil during transportation can be reduced with proper maintenance of vehicles. This would include a rigorous and proactive maintenance program • This risk can be further reduced through an adequate program of training of drivers and crews. This would include defensive driver	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
					• To reduce the risk of contamination of soils due to increased fuel deliveries		training, basic vehicle maintenance, and emergency control of spills. In order for the vehicle crews to be adequately able to control any spills at an early stage, the vehicles must be properly equipped with spill containment equipment (booms, sandbags, spades, absorbent pads, etc.). Responsibility for training lies with the transport contractor. Adequate training, maintenance, and equipment of transport crews should be included as a requirement for transport contracts. • The hydrochloric acid tanks are contained within an epoxy-coated, concrete lined and bermed facility that has been designed to contain 110% of the volume of the tanks in the event of a spill. This eliminates the potential impacts to soils from spills of hydrochloric acid. • Spills from the tailings thickener will flow by gravity to the mine reclaim water ponds at the southern toe of the existing fines residue deposit. From there they will be pumped back to the processing plant. . The area that would be affected by such a spill has already been impacted by the mining operation. • All employees will be trained in cleaning up of a spillage. The necessary spill kits containing the correct equipment to clean up spills will be made available at strategic points in the plant area		
OC Mining, Support infrastructure, TSF and Plant	Topsoil & subsoil stripping, opencast mining	Soils and land capability	Soil destruction and sterlization	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans	Keep mining development footprint restricted to layout plans	• No specific mitigation can be applied during the construction phase of the mine to prevent soil destruction, although an important measures should be the correct handling and stockpiling of topsoil as discussed in section 11 of this report.	Continuous	Contractor / ECO
OC Mining, Support infrastructure, TSF and Plant	Topsoil & subsoil stripping, Clearing of vegetation for openpit through wetlands and water courses as well as road crossings	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans	Keep mining development footprint restricted to layout plans	No specific mitigation can be applied during the construction phase itself to prevent loss of land capability considering that the land use will change to industrial. This however, does not prevent the mine from ensuring that disturbance and clearing should be confined to the footprint areas of the mine and not over the larger area. This can be done in the following ways: • Corridors should be secured around the mining footprint areas to ensure the current land use (grazing) can continue in a functional way during mining. • Clearly demarcate the entire development footprint prior to initial site clearance and prevent construction personnel from leaving the demarcated area. This could be done through the fencing off the entire development footprint and institute strict access control to the portions of the owner-controlled property that are to remain undisturbed as soon as possible after initial site clearance. The fence should preferably be impermeable (for example a solid wall) to discourage invertebrates and small animals from entering the site. [Normally solid perimeter walls are not recommended in order to facilitate the movement of invertebrates, but in this case restriction of their movement into the area will be advantageous.] • All development activities should be restricted to specific recommended areas and strict buffer zones should be applied around the sensitive areas. The Environment Control Officer (ECO) should demarcate and control these areas. Unnecessary bulldozing through the veld should be avoided.	Continuous	Contractor / ECO
OPERATIONAL PHASE									
OC Mining, Support infrastructure, TSF and Plant	Heavy machinery and vehicle movement on site, laydown areas of overburden dumps and stockpiles	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During operation, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by construction vehicles and equipment, wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. Vehicles should also stick to haul roads when dumping of overburden and topsoil are done. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment.	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							• Refer to mitigation measures needed during the construction phase that are similar to the mitigation measures for impacts during the operational phase.		
	Laydown areas of WRDs and stockpiles, crushing and stockpiling	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Rehabilitation: revegetate or stabilise all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed development to enhance the aesthetic value of the site and stabilize soil conditions; • The vegetative (grass) cover on the soil stockpiles (berms) must be continually monitored in order to maintain a high basal cover. Such maintenance will limit soil erosion by both the mediums of water (runoff) and wind (dust); • Conservation of topsoil should be prioritized on site and done as follows: ○ Topsoil should be handled twice only - once to strip and stockpile, and secondly to replace, level, shape and scarify; ○ Stockpile topsoil separately from subsoil; ○ Stockpile in an area that is protected from storm water runoff and wind; ○ Topsoil stockpiles should not exceed 2.0 m in height and should be protected by a mulch cover where possible; ○ Maintain topsoil stockpiles in a weed free condition; ○ Topsoil should not be compacted in any way, nor should any object be placed or stockpiled upon it; ○ Stockpile topsoil for the minimum time period possible i.e. strip just before the relevant activity commences and replace as soon as it is completed. • Refer to mitigation measures that are similar for impacts during the construction phase.	Continuous	Contractor / ECO
	Laydown areas of overburden dumps and stockpiles, materials handling and transportation, crushing and stockpiling	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Vehicle maintenance only done in designated areas – spill trays, sumps to be used and managed according to the correct procedures. • Vehicles and machines must be maintained properly to ensure that oil spillages are kept to a minimum. • Fuel and oil storage facilities should be bunded with adequate storm water management measures. • Operational and Maintenance plan and schedule for management of sewage facilities should be compiled. An emergency plan should be compiled to deal with system failures and should include a down-stream notification procedure • Routine checks should be done on all mechanical instruments for problems such as leaks, overheating, vibration, noise or any other abnormalities. All equipment should be free of obstruction, be properly aligned and be moving at normal speed. Mechanical maintenance must be according to the manufacturer's instructions • Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping, opencast mining	Soils and land capability	Soil destruction and sterlization	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• The most desired approach during all of the mining phases is to continually rehabilitate the soils to the best possible state – taking into account the current technology and knowledge available as well as the financial means to conduct such rehabilitation. The rehabilitation of soils to pre-mining conditions is basically impossible though. Refer to section 11 of this document for a detailed discussion on the rehabilitation of topsoil after stripping. • Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping, Clearing of vegetation for openpit through wetlands and water courses as well as road crossings	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase • Only a small area of the land should be used for mining at a time. Rehabilitation should take place on a continuous basis where after the land would become partially available again as grazing.	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
DECOMMISSIONING PHASE									
OC Mining, Support infrastructure, TSF and Plant	Demolition of mining infrastructure; Heavy machinery and vehicle movement on site	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure, Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure / Cessation of mining /	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Rehabilitation	Soils	Improvement of soils and repair of erosion damage through revegetation over time	NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
CLOSURE PHASE & POST CLOSURE PHASES									
OC Mining, Support infrastructure, TSF and Plant	Rehabilitation	Soils	Improvement of soils and repair of erosion damage through revegetation over time	NEMA Regulation 543 Section 32	• To ensure that the mining areas rehabilitated according to prescriptions • To shape and prepare the rehabilitation areas to blend in with the surrounding environment. • To rehabilitate all disturbed areas to a suitable post closure land use • To manage the social impact of closure on personnel who became redundant due to closure • To keep all the post closure monitoring in place and to ensure that the necessary reporting is done to the authorities and interested and affected parties	Rehabilitate within development footprint to ensure revegetation and rehabilitation impacts are kept within the mining footprint areas	• Plant vegetation species for rehabilitation that will effectively bind the loose material and which can absorb run-off from the mining areas. • Rehabilitate all the land where infrastructure has been demolished. • Monitor the establishment of the vegetation cover on the rehabilitated sites to the point where it is self-sustaining. • Protect rehabilitation areas until the area is self-sustaining. • Diversion trenches and storm water measures must be maintained • Water management facilities will stay operational and maintained and monitored until such a stage is reached where it is no longer necessary. • The mining areas will be shaped to make it safe. • All the monitoring and reporting on the management and rehabilitation issues to the authorities will continue till closure of the mine is approved.	Continuous	Ecologist / ECO
	Rehabilitation	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During closure, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by vehicles wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment. Other soil rehabilitation measures are discussed in section 11. • Soil should be sampled and analysed prior to replacement during rehabilitation. If necessary, and under advisement from a suitably qualified restoration ecologist, supplemental fertilisation may be necessary.	Continuous	Contractor / ECO
	Rehabilitation	Soils	Soil erosion and sedimentation	CONSERVATION OF	Refer to Construction Phase	Refer to Construction Phase	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
				AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	objectives	criteria			
	Rehabilitation	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Soils and land capability	Improvement of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Once mining activities have ceased, disturbed areas should be rehabilitated and the grazing capacity restored as high as possible. The rehabilitation of the soils and revegetation is discussed in section 11 of this report. • Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO

10 LAYOUT PLAN OPTIONS AND POTENTIAL IMPACTS

The potential risk associated with the layout options are impacts on the highly sensitive soils associated with the sloping terrain (erosion, compaction) and the seasonally wet clayey soils. These risks are mostly erosion and compaction risks on the laydown areas of the stockpiles and overburden dumps, as well as the movement of heavy vehicles during the different phases of the mine.

Different layout options were identified at a PFS level for the location of the Tailings Storage Facility (TSF) and the processing plant with subsequent different haul road and access road options. Table 19 indicates the most suitable layout option in terms of soil and land capability impacts. The 4 layout options and wetland overlay is indicated in Figure 15 to 18

Table 8. Preferred and alternative layout options for the proposed Doornhoek Fluorspar Project

Options	Positives	Negatives	Recommendation
Layout Option 1	• Plant location close to resource • Infrastructure generally on soils with low erosion potential	• Impacting on sensitive outcrop soils • Infrastructure generally on soils with high compaction potential	**2nd most suitable option from a soil impact point of view**
Layout Option 2	• Plant location close to resource • TSF generally on soils with low erosion potential	• TSF impacting on alluvial soils in drainage channel • Plant located on sloping terrain with high risk of erosion • Infrastructure generally on soils with high compaction potential	**4th most suitable option from soil impact point of view**
Layout Option 3	• Plant located close to access road for • Infrastructure generally on soils with low erosion potential	• Plant located further away from resource area • Impacting on sensitive outcrop soils • Infrastructure generally on soils with high compaction potential	**3rd – Most suitable option from a soil impact point of view**
Layout Option 4	• Plant location close to resource • Infrastructure generally on soils with low erosion potential	• Impacting on small area with sensitive outcrop soils • Infrastructure generally on soils with high compaction potential	**1st most suitable option from soil impact point of view**

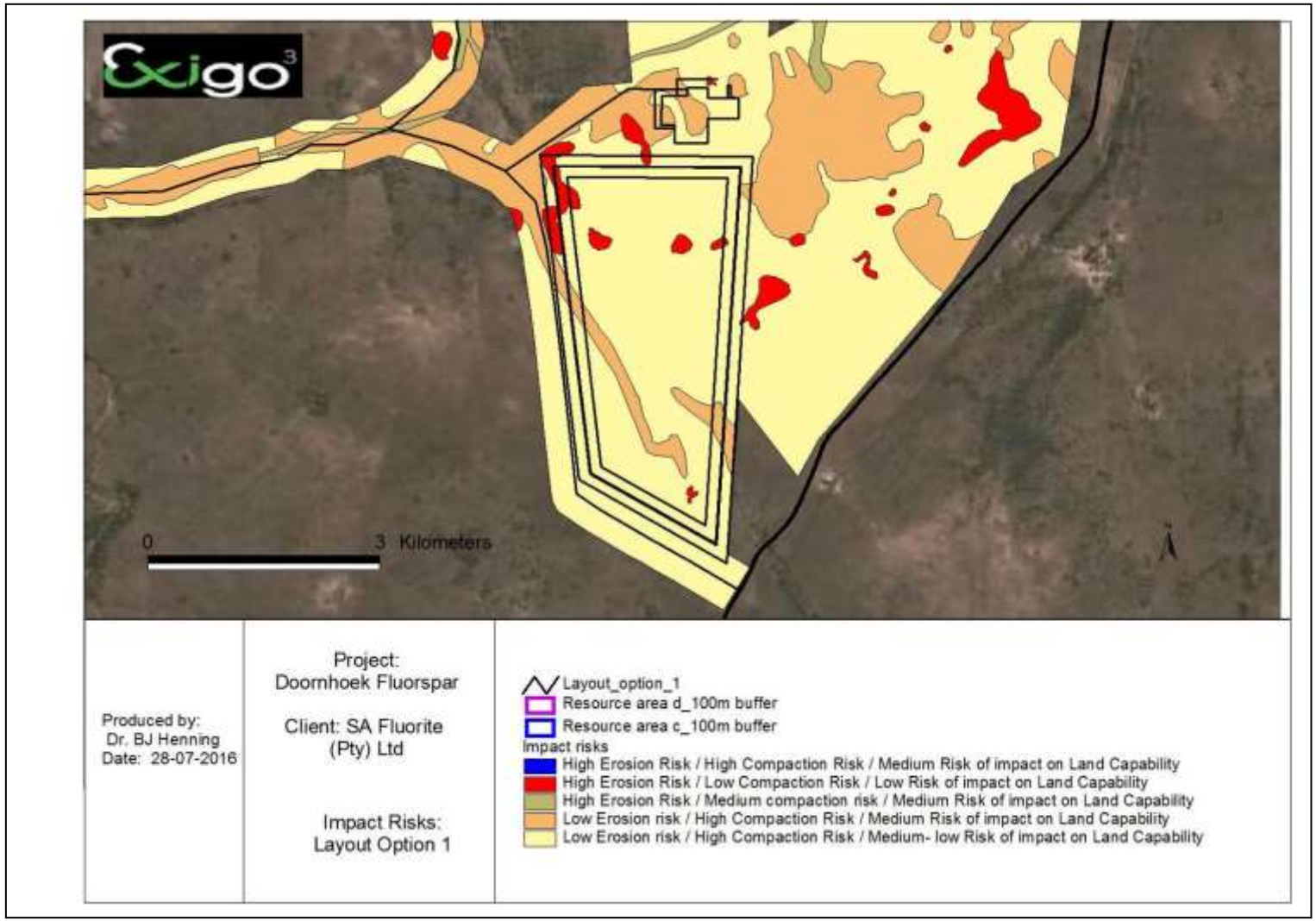


Figure 15. Layout option 1 Soil risks overlay map

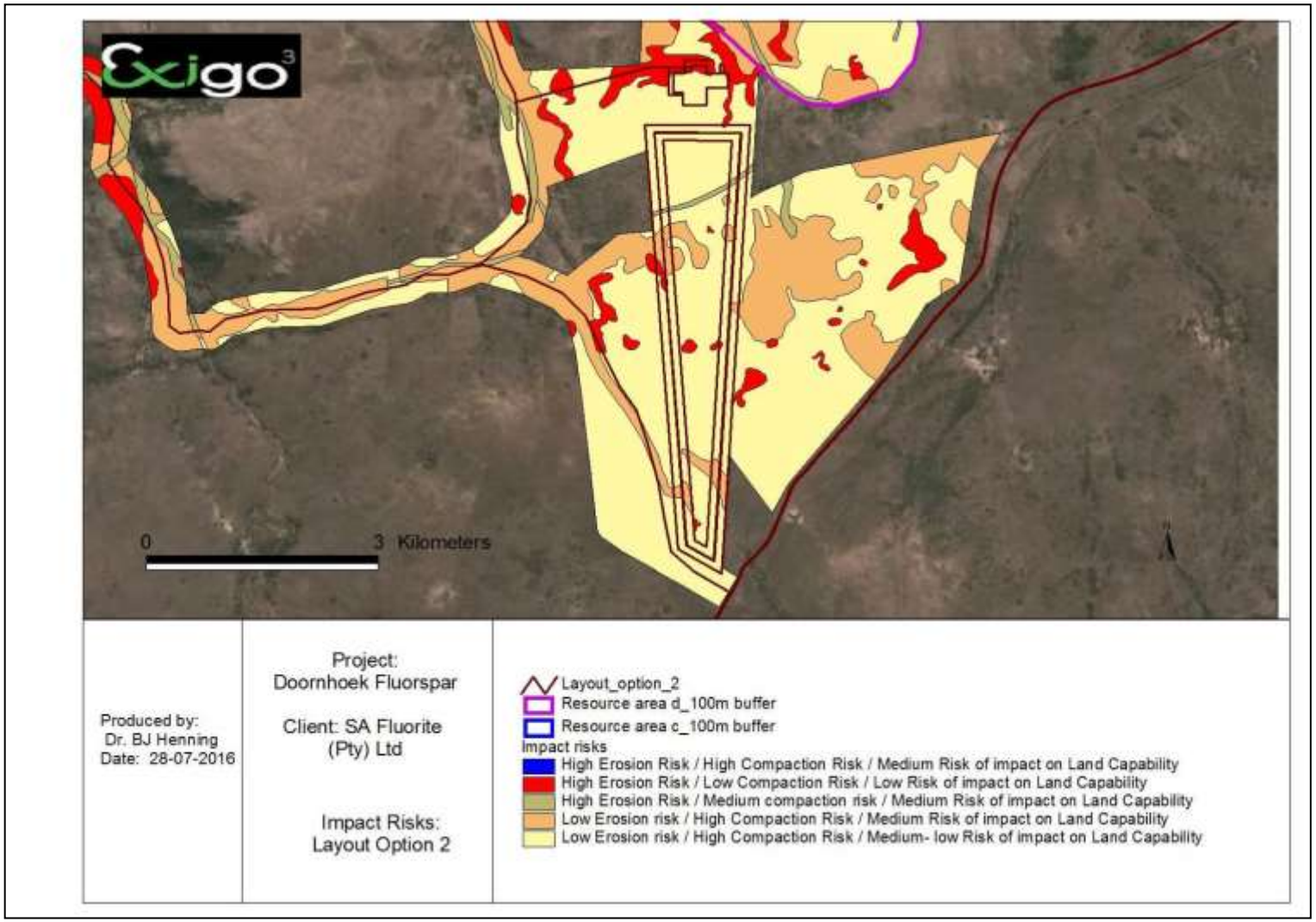


Figure 16. Layout option 2 Soil risks overlay map

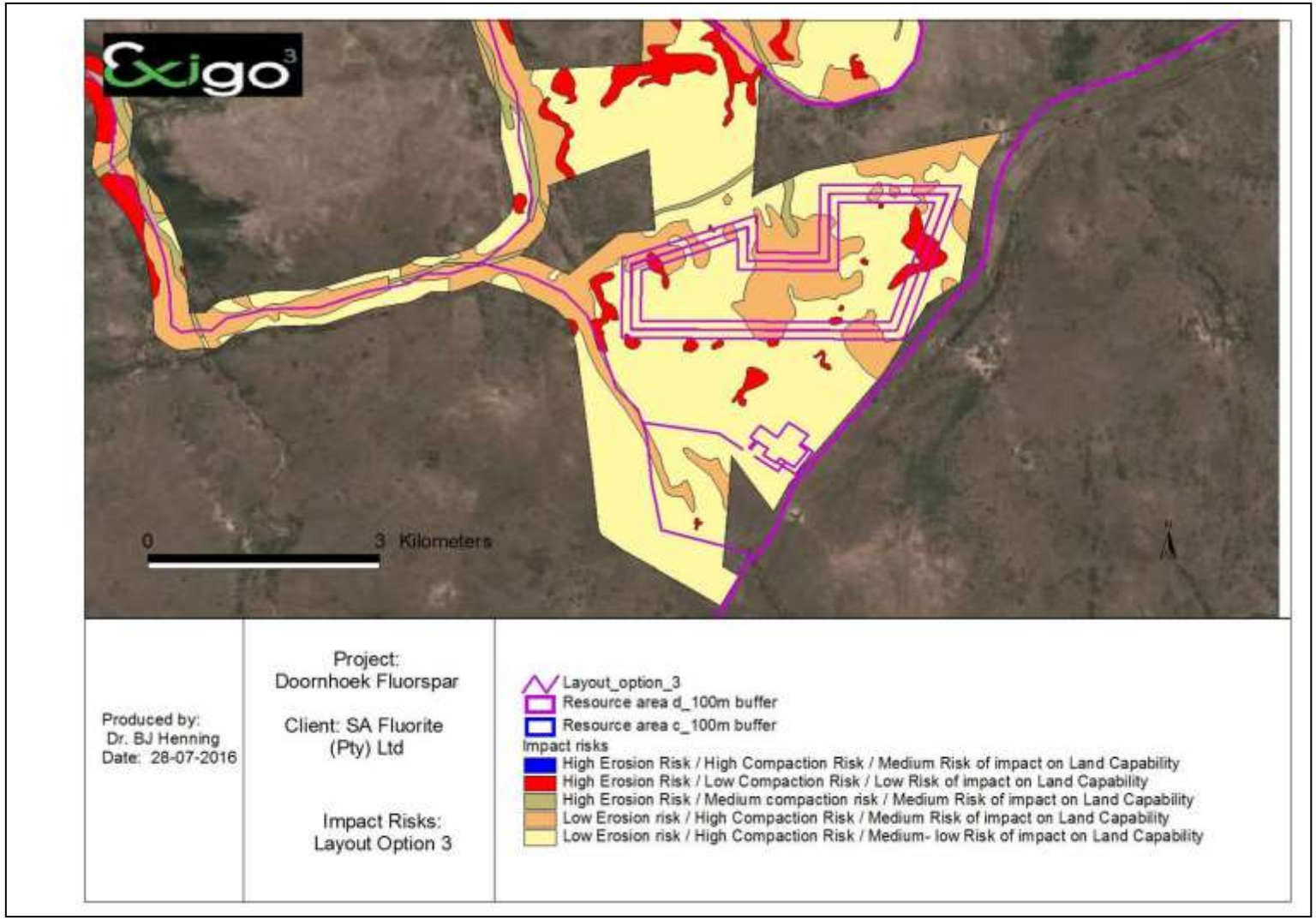


Figure 17. Layout option 3 Soil risks overlay map

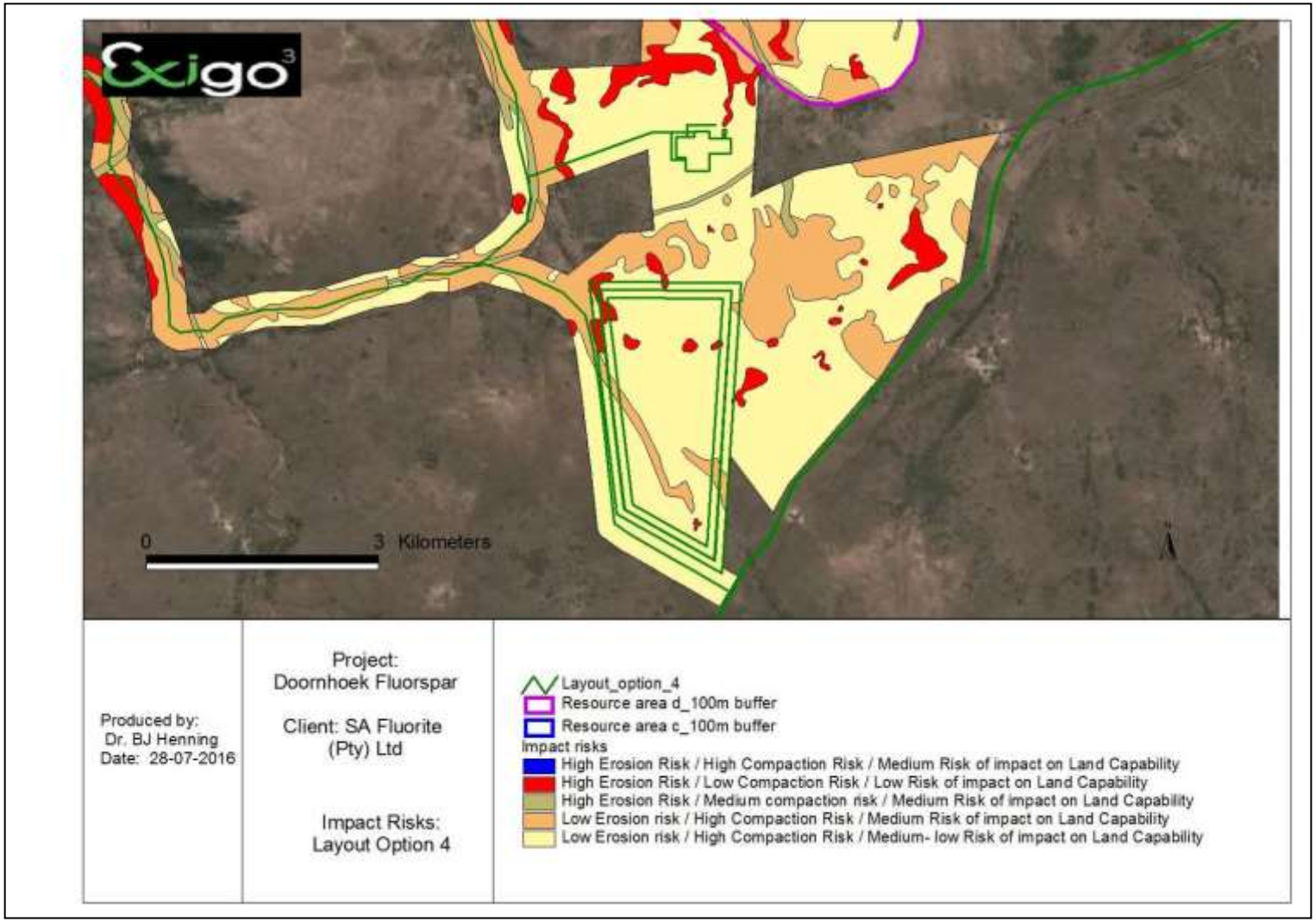


Figure 18. Layout option 4 Soil risks overlay map

11 REHABILITATION MEASURES FOR SOIL STABILISATION AND PROTECTION

Rehabilitation can be defined as the return of disturbed areas to a safe, stable, productive and self-sustaining condition that promotes bio diverse land use. Land rehabilitation techniques can be used to speed up the time required to restore the impacted area back to its original, or better, state. To re-create and maintain a sustainable environment it is important to plan how the areas to be impacted by the Doornhoek Fluorspar Mine will be rehabilitated and revegetated.

11.1 Best practices in rehabilitation planning and management

Use of rehabilitation planning and environmental management that aims for sustainability is encouraged in all aspects of reclamation planning, design and implementation. Environmental Guidelines by the Department of Water Affairs and Forestry (DWAF), 2005 aims to guide environmental management during all phases of a project lifecycle.

These Environmental Best Practice Guidelines for; Planning; Construction, Operation and Decommissioning Planning provide a scientific-based, comprehensive and integrated strategies to also perform rehabilitation for developments and therefore mitigate against safety hazards and environmental degradation.

11.2 Cleared Indigenous Plant Material

Where construction or rehabilitation activities are to commence in a specific area, certain indigenous plant material from the construction footprint area could be collected and bagged to be used in re-vegetation or as mulch during rehabilitation. To protect drainage areas and small streams as well as erosion prone areas, brush could be cut and used to *"brush pack"* these problem areas to protect it. This will also restrict movement of animals and humans over sensitive erosion probe areas until pioneer vegetation has established.

11.3 Topsoil, Stockpiles and backfilling

The manner in which topsoil and stockpiles are created and maintained is important with regards to the implementation of a successful rehabilitation process. Soil management practices must be adhered to in order to reduce soil loss and to encourage rehabilitation post-construction. The two most important aspects to consider when removing topsoil are the depth of soil to be removed and the conditions of storage.

The topsoil layer (0-25 cm) is important as it contains nutrients, organic material, seed, and communities of micro-organisms, fungi and soil fauna. The biologically active upper layer of soil is fundamental in the development of soils and the sustainability of the entire ecosystem. In the case of the study area very little areas with sufficient topsoil occur, and topsoil is limited to shallow depth (0-25cm in areas indicated in figure). The correct handling of topsoil is vital in

conserving the seed bank and nutrients which occur within this layer thereby ensuring successful rehabilitation.

- Topsoil must only be used for rehabilitation purposes and not for any other use example i.e. construction of roads.
- Previously excavated areas on the site should be backfilled with suitable topsoil, levelled to resemble the surrounding topography and slopes and scarified for re-vegetation/re-seeding.
- On steeper slopes rehabilitation measures may include systems such as soil terracing, berm creation, grass blocks, fascine work, gabion basket work, reno mattresses, retaining block mechanisms, sand bags, boulder and rock placement, stone pitching, and grading.
- Erosion control netting or matting (GeoJute or Bio-Jute) may be utilised on steep slopes to assist with soil retention, weed control and vegetation establishment. The netting material helps protect the soil from wind and water erosion, and the required rehabilitation plant material can be installed by making small incisions for planting. The netting is biodegradable and will eventually break down and form a mulch layer.

11.4 Compaction and Rehabilitation Measures

Soil compaction is often an effect of high traffic areas on development sites. It can become a major problem and can be recognized by:

- Excess surface moisture and slow drying soils due to deeper compaction preventing the percolation of water through the soil profile;
- Water runoff due to surface compaction preventing penetration and absorption (ponding of water), especially on banks and sloping surfaces.
- Large clear or sparsely covered areas devoid of a good vegetative cover due to hardened topsoil layers

The problems associated with compaction can be rehabilitated after mining has ceased as follows:

- Rip and/or scarify all disturbed areas, including roads that are no longer in use (preferably before the rainy season). Do not rip and/or scarify areas under wet conditions, as the soil will not loosen.
- Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment.

11.5 Erosion Rehabilitation Measures

Water has the gift to sustain life, but also the potential to maim, damage and destroy if not managed correctly. Remedial actions must be established to ensure that potential erosion is addressed with an erosion control strategy towards long-term rehabilitation. It is important to take note of the following generic points regarding erosion risks in the study area:

- Soil loss will be greater during wetter periods. However, the provision of erosion control measures for the through the drier months of the year is equally as important;
- Soil loss from the site is proportionally related to the time the soils are exposed, prior to rehabilitation. The time from commencement of rehabilitation activities to finalization thereof should be limited. Rehabilitation efforts should commence as soon as practical;
- Construction staging and progressive/concurrent rehabilitation is important; and
- The extent of the disturbance that will take place will influence the risk and consequences of erosion on the site.
- Avoid over-wetting, saturation and unnecessary run-off during dust control activities and irrigation.
- Retain natural indigenous grass and shrubs and re-vegetate bare areas as soon as possible.

11.6 Re-Vegetation

Plant species that have been rescued or removed and relocated to the temporary nursery could be used in replanting rehabilitation areas.

Additional plant material (indigenous trees) as required should be sourced from local indigenous nurseries and specifications regarding plant sizes, heights and the installation process of these plants should be developed by the On Site ECO and Rehabilitation Specialist. Standard horticultural best practice would apply, with specific reference to the fact that the plant material would have to be in good condition, free from pests and diseases (any such plant would have to be removed from the site), well formed and well rooted, potting materials are weed free and with

sufficient root cover. Groundcovers and sedges are often supplied in trays, and the same standards would apply.

- A grass seed specification for reseeding the rehabilitated areas is included below. Re-grassing should be undertaken (as far as possible) during the summer months, as germination and establishment is best at this time of year. Spring rains are also conducive to good germination results, and as such rehabilitation programmes should take these factors into consideration.
- There are two methods for seeding, hand broadcasting and hydro-seeding. The methods utilised will be site specific and the On Site ECO and Rehabilitation Specialist will determine them.
- In certain areas grass runners may be required, and grass sods where instant cover is necessary.
- A typical grass seed mixture (hand sowing) that could be implemented for rehabilitation activities will include: (specification 4-5kg/ha)
    - *Eragrostis tef* (Tef);
    - *Eragrostis curvula* (Weeping Love Grass);
    - *Digitaria eriantha* (Smutsvinger);
    - *Cynodon* spp. (Bermuda kweek);
    - *Panicum maximum* (Witbuffel);
    - *Chloris gayana* (Rhodes grass);
    - *Paspalum notatum (Bahia Grass)*

12 DISCUSSION & CONCLUSION

This study addresses the agricultural potential, land capability and general characteristics of the soils on the site for the development of the Doornhoek Fluorspar Mine in the North West Province. The results obtained from the study were done after field observations were done to verify the soil potential classified by the Department of Agriculture on a small scale.

By definition, based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, the proposed area, earmarked for the development of the Fluorspar Mine can be classified as having soil potential that vary from Medium to low. The soil forms identified in the study area and the subsequent land capability is summarised in Table 8.

Table 9. Soil forms, land capability and potential of the proposed mine

Soil Forms	Land capability
Very shallow exposed bedrock outcrops / Shallow Mispah soil form occurring throughout the study area on the undulating plains and ridges;	Class VII: Very severe limitations. Suitable only for natural vegetation
Shallow, gravelly soils of the Hutton or Glenrosa soil form along the plateaus and slightly undulating terrain of the study area	Class VI: Limitations preclude cultivation. Suitable for perennial vegetation.
Deep red apedal soils of the Hutton soil form	Class IV: Severe limitations. Low arable potential. High erosion hazard.
Shallow sandyclay to sandyclayloam soils associated with seepage zones (Avalon / Longlands soil forms);	Class V: Watercourse and land with wetness limitations
Black clayey / alluvial soils of the Rensburg / Katspruit soil forms associated with drainage channels	Class V: Watercourse and land with wetness limitations

The density of the vegetation and grazing capacity of the land would allow grazing of the area, especially on the larger farm portions that can sustain economically viable grazing. The proposed mining development will cause a loss of grazing value of the land, although site specific mitigation needs to be implemented.

The land capability of the site is mostly restricted to wildlife grazing due to the shallow and often sandy nature of the soils and location of pockets of seasonally wet soils in some areas. The potential impacts associated with the proposed development are soil disturbance (erosion, compaction), loss of land capability, soil destruction and sterilisation and soil pollution (spillages).

The site should subsequently be considered as being valuable grazing land with limited potential for arable agriculture considering the climatic conditions.

Four primary layout options were considered based on potential risk of impact on soils and land

capability. Mitigation measures are provided in the report for the impacts and provided this management and rehabilitation measures stipulated in the report are strictly adhered to, the mining development could be supported.

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