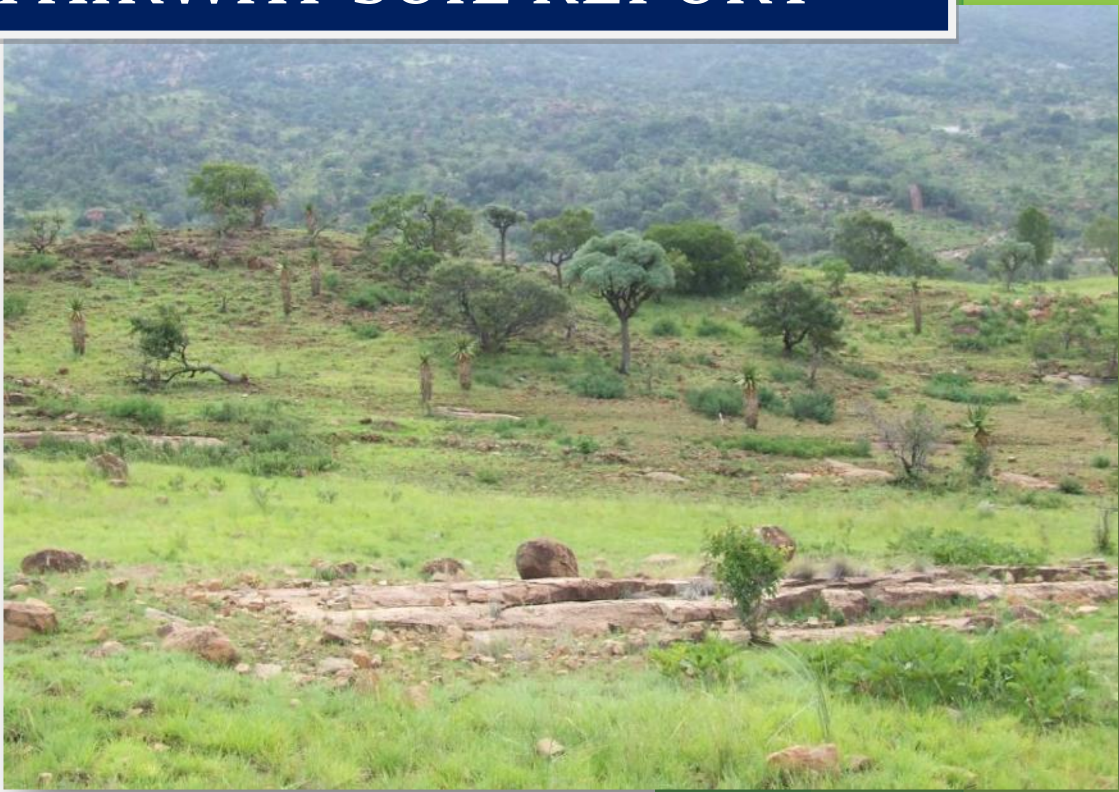
January 2012

PROJECT FAIRWAY SOIL REPORT



SOIL AND LAND CAPABILITY STUDY FOR THE PROPOSED UNDERGROUND MINING OPERATION OF PROJECT FAIRWAY

PREPARED FOR

PREPARED BY

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Executive summary

Based on the findings of the soil and land capability study it is the opinion of the soil scientists, from a soil conservation and land capability point of view, that the proposed development be considered favorably provided that due care is taken to minimise impacts on soils and land capability through the minimization of footprint areas and through good soil management principles as outlined in the stripping and stockpiling plan included in this report.

Introduction

Scientific Aquatic Services cc in association with Terra Africa Consult cc was appointed by Aquarius Platinum (South Africa) (Pty) Ltd to conduct a soil and land capability study for the proposed extension of its mining operations at Everest Platinum Mine. The proposed project is referred to as Project Fairway and aims to establish the necessary infrastructure to enable the underground mining of the Booysendal South mining block located immediately west of the existing Everest mine. The mine is located on the farms De Kafferskraal 53-JT, Sterkfontein 52-JT and Sterkfontein 749-JT, in the Thaba Chewu Local Municipality within the Ehlanzeni District Municipality. In addition to the project fairway activities and associated to the additional production from these facilities, a new Tailings Storage Facility (TSF) is proposed which is to be located immediately to the north of the existing TSF complex. Current operations at Everest comprise of an underground mine, mineral processing operations, a tailings dam, water management infrastructure and various support services and networks.

Land type data

The entire area where the proposed TSF consists of only one land type i.e. Ab29. The texture classes range from sandy clay-loam to clay-loam. Slopes in this land type range between 0 to 15% and the soil is underlain by gabbro and norite of the Rustenburg complex. Soils in this land type can generally be described as red-yellow apedal freely-drained soils.

Two land types were identified in the proposed infrastructure area i.e. Ib31 and Ib154. Most of the Ib31 land type is rock with limited soil and shallow soil forms and thus dominated by the Mispah soil form. Most areas in this land type have slope ranging from 3% to 50% with clay content in the shallow topsoil ranging between 1-3%.

The Ib154 land type consists of a combination of shallow rocky soil of the Mispah and Glenrosa soil forms while terraces are composed mainly of massive or structured soils with low to medium base status. Soils in this land type have higher clay content of up to 40%.

Physical soil properties

Five different soil forms are present in the proposed TSF area that can be divided into two groups i.e. soil with high agricultural potential and hydromorphic (wetland) soils. Although the proposed footprint of the TSF is planned to be slightly smaller, it was considered beneficial to include a slightly larger area to accommodate an additional area that might be affected. The high agricultural potential soils include soils of the Hutton, Shortlands and Clovelly forms while wetland soils consist of a mixture of Kroonstad and Katspruit forms. The areas for these soil forms are summarised in Table A.

Table A: Summary of soil forms in the TSF area

SUMMARY OF SOIL FORMS IDENTIFIED FOR THE TSF AREA OF PROJECT FAIRWAY			
SOIL FORM	MAP COLOUR	AREA (ha)	% OF FOOTPRINT AREA (%)
Hutton		12.8	12.0
Shortlands		75.5	70.8
Clovelly		11.9	11.2
Katspruit/Kroonstad		6.5	6.1
TOTALS		106.7	100.0

Five different soil forms are present in the proposed infrastructure area that can be divided into three broad groups i.e. shallow rocky soils (Glenrosa, Mispah and rocky outcrops), shallow to medium-deep structured soils (Shortlands soil form) that were identified in areas with plateaus or valley bottoms and hydromorphic (wetland) soils (Arcadia and Rensburg soils). Although the current footprint of the infrastructure will be much smaller, it was considered beneficial to include an additional area for mapping purposes.

Table B: Summary of soil forms in the infrastructure area

SUMMARY OF SOIL FORMS IDENTIFIED FOR THE INFRASTRUCTURE AREA OF PROJECT FAIRWAY			
SOIL FORM	MAP COLOUR	AREA (ha)	% OF STUDY AREA (%)
Glenrosa/Mispah/Rock		210.5	80.1
Shortlands		24.8	9.4
Arcadia/Rensburg		27.4	10.4
TOTALS		262.7	100.0

Chemical soil properties

The pH(H_2O) of the analyzed soil samples ranges between 5.3 and 5.6 and this can be described as strongly acid. Should the entire site have consisted of soils with high agricultural potential, it would have required the addition of agricultural lime to improve crop yield and plant performance.

Potassium levels are generally deficient ranging from 19 to 93 mg/kg. Potassium uptake by plants is further decreased by the dominance of the cation complex by high calcium and magnesium levels.

The phosphorus (P) level measured is 2 mg/kg. Although this seems very low for a crop production situation, it is normal for South African veld conditions. The calcium and magnesium levels are high in all samples but are a natural occurrence in the area of the study site. The sodium levels are acceptable ranging at 0.2 to 0.6 mg/kg and indicated no sodicity.

Land capability

The soil and land types identified in the TSF study area could be classified into two land capability classes i.e. land with arable land capability (the Hutton, Shortlands and Clovelly soil forms) as well as land with wetland land capability (Kroonstad/Katspruit forms). The areas with arable land capability (100.3ha) are suitable for both irrigated and dryland crop production. The areas with wetland land capability (6.5ha) are suitable for conservation and grazing purposes. However, overgrazing should be avoided that will result in trampling of wetland areas.

10.3. Fairway infrastructure area

The infrastructure area associated with the proposed Project Fairway can be divided into land with three different land capabilities. The area is dominated by wilderness land capability (210.5ha) due to the very shallow, rocky nature of soil forms present as well as the steep slopes. The main use of this land capability unit should be conservation due to the extreme high levels of biodiversity that occurs in the area (as well as it being a centre of floristic endemism). The slightly deeper soil profiles in the valley bottoms on plateaus can be classified as land with grazing land capability (24.8ha). These areas are more suitable for cattle and game farming. Areas with wetland land capability (27.4) are mostly drainage lines, and marshy areas, largely associated with the Groot Dwars River floodplain. These areas are suitable for conservation and light grazing.

Environmental impacts

The following impacts on soil and land capability are anticipated for the project:

- Soil erosion due to steep slopes and vegetation clearance
- Topsoil degradation
- Soil compaction due to regular heavy vehicle transport
- Chemical soil pollution as a result of potential spillage of petroleum hydrocarbons and other soil pollutants
- Loss of agricultural potential and arable land capability in TSF area
- Loss of wetland land capability in TSF and infrastructure areas
- Loss of grazing and wilderness land capability in the infrastructure areas

Table C below indicates the rating assigned for each impact with regards to severity, duration and spatial scale for unmitigated and mitigated scenarios.

Table C: Summary of impacts on soil and land capability

Impact	Unmitigated			Mitigated		
	Severity	Duration	Spatial Scale	Severity	Duration	Spatial Scale
Soil impacts						
Soil erosion	High	High	Low	Medium (+)	Medium	Low
Topsoil degradation	High	High	Low	Medium (+)	Medium	Low
Soil compaction	High	High	Low	Low (+)	High	Low
Soil chemical pollution	High	Low	Medium	High (+)	Low	Low
Land capability impacts						
Loss of arable land capability	High	High	Low	High (+)	High	Low
Loss of grazing/wilderness land capability	Medium	Medium	Low	Medium (+)	Medium	Low
Loss of wetland land capability	High	High	Low	High	High	Low

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1. INTRODUCTION

Scientific Aquatic Services cc in association with Terra-Africa Consult cc was appointed by Aquarius Platinum (South Africa) (Pty) Ltd to conduct a soil and land capability study for the proposed extension of its mining operations at Everest Platinum Mine. The proposed project is referred to as Project Fairway and aims to establish the necessary infrastructure to enable the underground mining of the Booysendal South mining block located immediately west of the existing Everest mine. The mine is located on the farms De Kafferskraal 53-JT, Sterkfontein 52-JT and Sterkfontein 749-JT, in the Thaba Chewu Local Municipality within the Ehlanzeni District Municipality.

Current operations at Everest comprise of an underground mine, mineral processing operations, a tailings dam, water management infrastructure and various support services and networks. The main components of Project Fairway comprise new boxcuts, a new tailings storage facility, changes to the processing plant and various support services and infrastructure.

A soil survey of the mining area was conducted during October 2011 by M. Pienaar of Terra-Africa Consult cc, a registered Professional Natural Scientist in soil sciences. The purpose of the study was to determine the soil forms and current land capability of the area where the proposed underground mining infrastructure will be constructed as well as the area for the new tailings storage facility. Soil samples for chemical analysis were also sampled during the site visit.

The objectives of this survey are:

- to describe the soils (distribution, types, depth, surface features, wetness hazard and cultivation factors per horizon, suitability for agriculture and 'topsoil', physical and chemical characteristics, fertility, erodibility, dry land production potential and irrigation potential),
- to determine the pre-development land capability,
- to conduct an Impact Assessment for the soils and land capability which will feed into the overall Environmental Impact Assessment, and

- to propose mitigation measures for the impacts to form part of the Environmental Management Programme

Since agricultural potential of land is largely determined by the soil characteristics together with climatic conditions, a soil survey was conducted to establish homogenous soil units and their distribution. These units could in turn be assessed in terms of agricultural potentials for different farming operations like animal production and irrigated crop production taking the rainfall, temperature and soil potential into consideration.

2. GENERAL BACKGROUND INFORMATION

Aquarius Platinum SA (Pty) Limited (AQPSA) is the South African operating subsidiary of Aquarius Platinum Limited (AQP) which is currently listed on the Australian, London and Johannesburg stock exchanges. AQPSA currently operates four (4) mines in South Africa: Kroondal Platinum, Marikana Platinum, Blue Ridge Platinum and Everest Platinum. Everest Platinum is situated between Roossenekal and Lydenburg in Mpumulanga Province and mines Platinum Group Metals (PGMs). The mine is located on the eastern limb of the Bushveld Complex.

Everest comprises mining operations, mineral processing, waste and water management and various support services. The ore body being mined is the platinum bearing UG2 reef. The ore body is currently mined using underground mining methods. There is one mineral processing plant at the mine for extracting platinum group metals (PGM) and chrome from the ore. Ore from the mining operations is transported via a conveyor system to a primary crusher, from where it is conveyed to the plant for processing. Product (platinum filter cake) from the plant is transported to Impala's Refining Services near Rustenburg for further processing. Prior to disposal on a facility, the tailing is passed through a chrome recovery (spiral) plant. The chrome concentrate is then sold to chrome off-takers.

Tailings from the plant are pumped to a professionally engineered tailings dam. General domestic and industrial hazardous waste is collected and temporarily stored onsite before being disposed of off-site at permitted waste disposal facilities in Holfontein and Lydenburg.

There are storm water management and pollution control facilities at the mine including two sewage plants, a return water dam and pollution control dams (process / storm water dams).

There is an existing access road to the mine, off the Roossenekal-Lydenburg road (R577) with a security point. There is a network of internal service roads. One of these services the existing Valley decline. There are existing contractor's areas (offices, workshops, stores, changes houses) at the mine, as well as an Aquarius office complex located near the processing plant.

AQPSA is planning to extend its mining operations at Everest Platinum and is in the process of acquiring the Booysendal South mining block from Northern Platinum. The proposed project is now referred to as Project Fairway and aims to establish the necessary infrastructure to enable the underground mining of the additional mining block located immediately west of the existing Everest Platinum mine. For this project the following is proposed:

- Ongoing exploration drilling
- Extension of the underground mining operations to the ore body on the western side of the valley – this will be done by establishing new boxcuts
- A new surfaced access road (approximately 8km long) into the valley to service the boxcuts
- Ventilation shafts on the eastern and western side of the valley, with associated gravel service tracks
- Support facilities for the new boxcuts
- Change to infrastructure at the existing valley decline
- A new tailings storage facility (located on the terrace and potentially similar in size to the existing facility)
- Potential process changes to the existing plant to accommodate an increase in capacity from 250,000 to 280,000 tonnes/month
- Extension to existing services at the mine

It is the intention of AQPSA to limit the infrastructure that is developed in the valley and to maximise the use of existing infrastructure at the mine. In addition to that mentioned above, at this stage in project planning the following support facilities are also envisaged:

- Emergency ore storage facility;
- Offices, control room and transformer;
- Chairlift platforms, parking area and bus drop-off facility;
- Sumps, settling dams and service water storage facilities;
- An explosive off-loading facility;

- Lighting masts;
- Change house;
- Compressor station.

Some or all of the above facilities could be located at each of the boxcuts.

3. LOCALITY OF EVEREST PLATINUM MINE

The Everest Platinum Mine is located on the southern portion of the eastern limb of the Bushveld Complex on the eastern escarpment, next to the Steenkampsberge. The De Berg peak in the Steenkampsberge is the highest mountain peak in Mpumalanga. The site falls within the Groot Dwars River Catchment Area, a tributary of the Steelpoort River in the Olifants River Basin.

The mine is situated in the province of Mpumalanga near the border of Limpopo Province and the nearest towns are Roossenekal, approximately forty (40) kilometres to the west, Lydenburg (Mashishing) thirty (30) kilometres to the east and Dullstroom approximately forty (40) kilometres to the south. The site falls within the magisterial district of Lydenburg and the regional authority is the Ehlanzeni District Council. The proposed new developments will consist of a tailings storage facility (TSF) and other infrastructure associated with underground mining (**Figure 1**).

The following farms are present in the project area:

- Sterkfontein 52 JT;
- De Kafferskraal 53 JT;
- Sterkfontein 749 JT (Former Portion 26 of De Kafferskraal 53 JT and former Portion 7 of Sterkfontein 52 JT);
- Hoogland 38 JT (Former Portion 2 of Sterkfontein 52 JT and former Portion 28 of De Kafferskraal 53 JT)

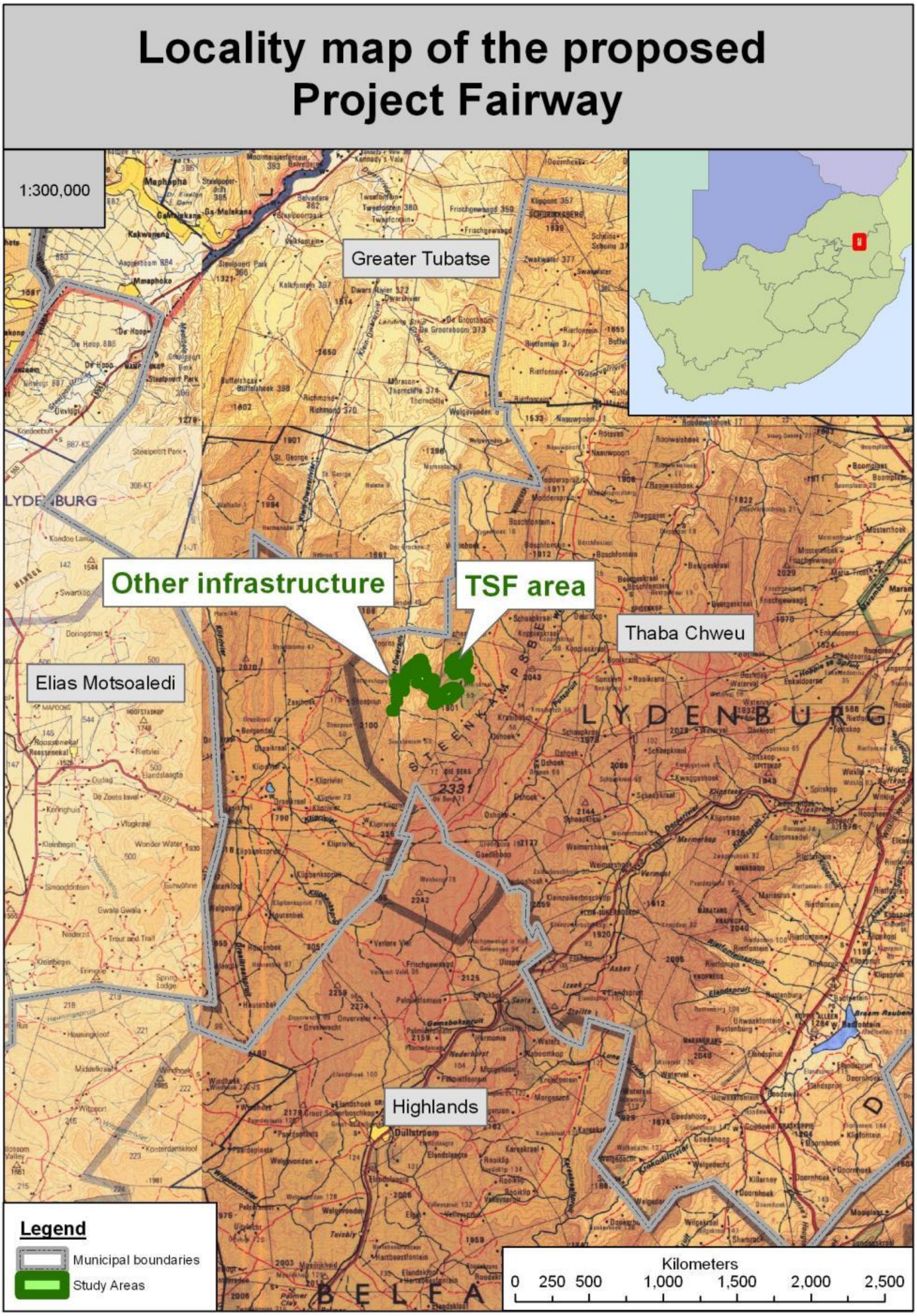

Figure 1: Locality map for the proposed Project Fairway

4. REGIONAL CLIMATE

A short description of the site climatic data is taken from the GCS report on their Hoogland study (GCS, August 2011) and the Groundwater Study for Project Fairway by FutureFlow (February, 2012):

"According to Janse van Vuuren, et al., (2003 loc cit, CSIR 2004b) the Mean Annual Precipitation varies from 500 mm in the lower parts of the catchment (Steelpoort and Burgersfort areas), to between 600 and 700 mm in the middle reaches and to a maximum of 800 mm around Belfast and Lydenburg area. The mean annual evaporation ranges from 1 300 mm in the east to 1 700 mm at the De Hoop Dam site in the west.

The rainfall data records that were obtained from the mine for the 2008/2009 hydrological year indicates the total rainfall of 1 067 mm for this period. The months where the highest rainfall was recorded, occurred during November 2008 and February 2009, when 298 and 286 mm were recorded respectively. The total rainfall that was recorded is significantly higher than the average rainfall figures that were obtained for the Lydenburg (Mashishing) weather station."

5. GENERAL GEOLOGICAL DESCRIPTION OF THE AREA

The following description of the general geology of the area was obtained from the existing EMPR:

"Everest South is a UG2 reef resource in the southern part of the eastern limb of the Bushveld Complex. The Bushveld Complex consists of two lithologically distinct units that are mainly intrusive into the Transvaal Supergroup: a lower sequence of layered mafic and ultramafic rocks, known as the Rustenburg Layered Suite (RLS), and an overlying unit of granites, known as the Lebowa Granite Suite. All the chromitite and platinum mineralization is located in the RLS. These layered rocks have a maximum thickness of up to about 8 km and occur in four areas known as the western, Potgietersrus, eastern and Bethal lobes.

The Rustenburg Layered Sequence comprises five stratigraphic zones as follows:

- the Marginal Zone, which comprises pyroxenites and norites with no economic potential;
- the Lower Zone which comprises ultramafic rocks, such as pyroxenites and harzburgites, containing thin, high-grade chromitite seams;
- the Critical Zone pyroxenites, norites and anorthosites that host all the significant PGM and chromite deposits;
- the Main Zone, which consists mainly of homogeneous norites and gabbros that are locally exploited as dimension stone;
- the Upper Zone norites, gabbros and diorites, which host over 20 massive magnetite seams, some of which are exploited for vanadium and iron ore.

The Lower, Critical and Main Zones become attenuated towards the southern end of the eastern lobe of the Bushveld Complex. For this reason, the Lower and lower Critical Zones are absent at Everest South.

The Everest South resource is one of the only two known deposits preserved on the east side of the Groot Dwars River valley. Its preservation may be attributed to relatively small-scale (1-5 km) undulations of the floor-rock contact. These consist of synformal or basin-like lows, separated by antiformal structures cored by Transvaal sandstones and the Marginal Zone. Erosion has removed the UG2 Reef along antiforms.

The Marginal, upper Critical and lower part of the Main Zones are all present in the project area, with the MG4, UG1 reef and UG2 reef chromitite reefs being the only well-developed mineralised units. Overlying units such as Merensky reef are absent in due to erosion."

6. LITERATURE REVIEW

A selection of literature and maps have been reviewed in order to gain a better understanding of the conditions of the area, as well as literature regarding some general aspects of the agricultural potential of the study area. Land Type data as provided by the Institute for Soil, Climate and Water were studied as well as the EMPR for the existing Everest Mine.

7. IMPACT ASSESSMENT METHODOLOGY

The method as prescribed by Metago Environmental Engineers was used for impact assessment. Impacts are assessed based on consideration of the impact severity, spatial scale and duration of impacts, which together determines the impact consequence. The impact consequence together with the probability of the impact occurring determine the overall impact significance.

The criteria for determining the severity, spatial scale and duration of potential impacts are given in Table 5. The criteria are based on the criteria detailed in *DEAT (2002) Specialist Studies, Integrated Environmental Management Information Series 4, Department of Environmental Affairs and Tourism (DEAT), Pretoria*; *DEAT (2002) Impact Significance, Integrated Environmental Management Information Series 5, Department of Environmental Affairs and Tourism (DEAT)* and the criteria and methodology developed by Theo Hacking[1].

Table 1: Criteria for assessment of impacts

PART A: DEFINITION AND CRITERIA*		
Criteria for ranking of the SEVERITY of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national

[1] Hacking, Theo (1999) An innovative approach to structuring environmental impact assessment reports. Anglo American Corporation-Envirolink. Unpublished.

7.1 Mitigation measure development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

- Mitigation and performance improvement measures and actions that address the risks and impacts are identified and described in as much detail as possible.
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation.
- Desired outcomes are defined, and have been developed in such a way as to be measurable events with performance indicators, targets and acceptable criteria that can be tracked over defined periods, with estimates of the resources (including human resource and training requirements) and responsibilities for implementation.

8. LAND TYPE DATA ASSESSMENT

8.1 Background information

The following abstract from Sililo et al. (2000) gives an introduction into the development and usefulness of a land type data system:

"In South Africa, land type maps were designed to assist in assessing agricultural potential. The procedure followed in mapping land types was described by the Institute of Soil, Climate and Water (Land type Survey Staff, 1987). The first step involved collecting and studying existing information and maps, including satellite imagery, relevant to the terrain, soils and climate of a given area.

After an orientation excursion, areas called terrain types, each displaying a marked uniformity of terrain form, were delineated. The soils within each terrain type were then identified and areas known as pedosystems, each displaying uniform terrain and soil pattern, were delineated. The soil composition of a terrain type was described by detailing which soil series of the Binomial System (MacVicar et al., 1977) occur on each terrain unit and by giving an estimate of the area of each soil type on a given terrain unit. A separate map showing climate zones was then drawn.

This was superimposed upon the pedosystem map to arrive at a map of land types. On completion of these steps, the land type boundaries were transferred from the 1:50 000 to the 1:250 000 maps. Finally, an inventory of each land type was compiled in terms of terrain, soil and climate parameters."

Land type data indicate broad soil groups, clay percentage as well as other information regarding the area that can be used to interpret soil classification results more successfully.

8.2 Land type results

8.2.1 Tailings Storage Facility (TSF) Area

The entire area where the proposed TSF will be consists of only one land type i.e. Ab29 (**Figure 2**). The texture classes range from sandy clay-loam to clay-loam. Slopes in this land type range between 0 to 15% and the soil is underlain by gabbro and norite of the Rustenburg complex. Soils in this land type can generally be described as soils red-yellow apedal freely-drained soils.

8.2.2 Infrastructure area

Two land types were identified in this area i.e. Ib31 and Ib154 (**Figure 3**). Most of the Ib31 land type is rock with limited soil and shallow soil forms and thus dominated by the Mispah soil form. Most areas in this land type have slope ranging from 3% to 50% with clay content in the shallow topsoil ranging between 1-3%.

The Ib154 land type consists of a combination of shallow rocky soil of the Mispah and Glenrosa soil forms while terraces are composed mainly of massive or structured soils with low to medium base status. Soils in this land type have higher clay content of up to 40%.

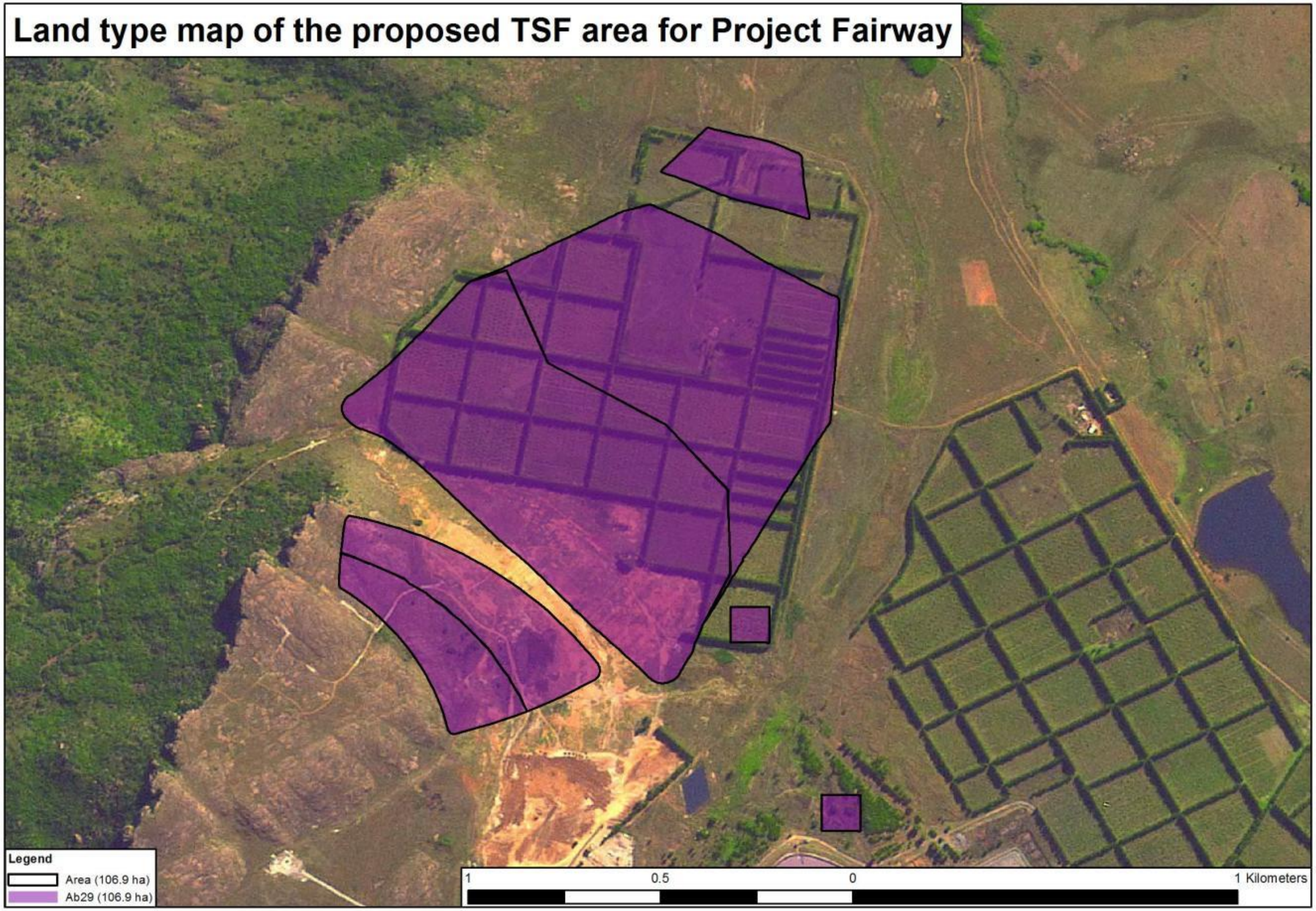

Figure 2: Land type map of the proposed TSF area for Project Fairway

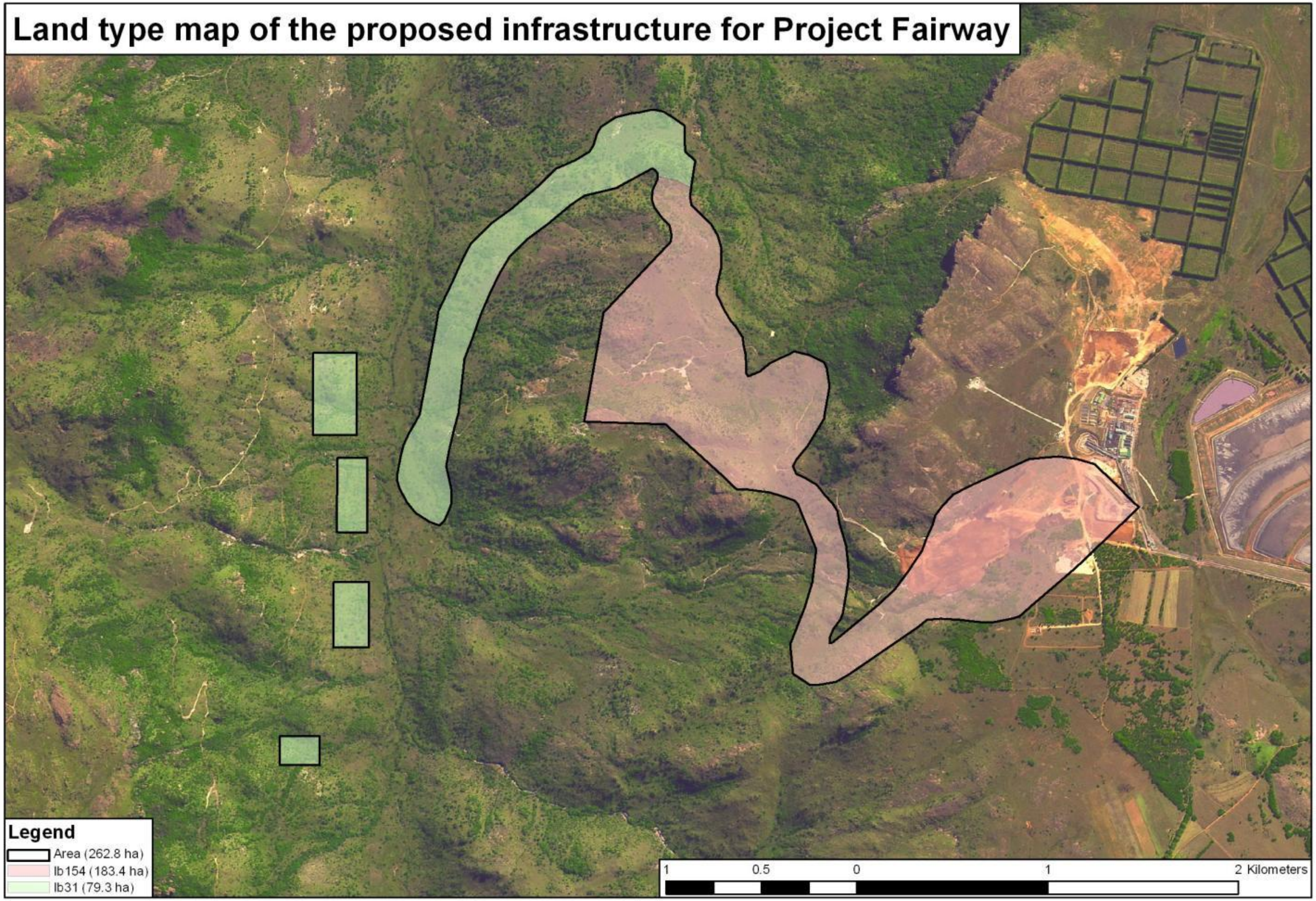

Figure 3: Land type map for the proposed infrastructure areas of Project Fairway

9. SOIL CLASSIFICATION

9.1 Survey method

A systematic soil survey was undertaken with sampling points between 50 and 100m apart on study area. Seventeen survey points were observed in the TSF area (**Figure 4**) and thirty-nine for the infrastructure area (**Figure 5**) Observations were made regarding soil texture, structure, organic matter content and slope of the area. Due to the very shallow nature of the all the soil forms present on site and the presence of hard rock, weathering rock and many rock particles it was often not possible to drill deeper than 0.2 meter.

The soils are described using the S.A. Soil Classification Taxonomic System (Soil Classification Working Group, 1991) published as memoirs on the Agricultural Natural Resources of South Africa No.15. Soils are grouped into classes with relatively similar soil characteristics. The soil class nomenclature was initiated during the national land type survey conducted by the Soils and Irrigation Research Institute, Department of Agriculture in Pretoria in 1991. Soils are grouped into classes with relatively similar soil properties and pedogenesis. A cold 10% hydrochloric acid solution was used on site to test for the presence of carbonates in the soil. A broad soil group reference based on international standards is also described.

Six soil samples (four topsoil and two subsoil) were collected in this area, stored in perforated soil sampling plastic bags on site and sent per courier to SGS Soil Laboratory in South Africa for chemical soil analysis. Samples were analyzed for pH, phosphorus content, macro nutrients (calcium, magnesium, and potassium), micro elements (iron, zinc, copper, etc.), organic carbon and electrical conductivity (resistance).

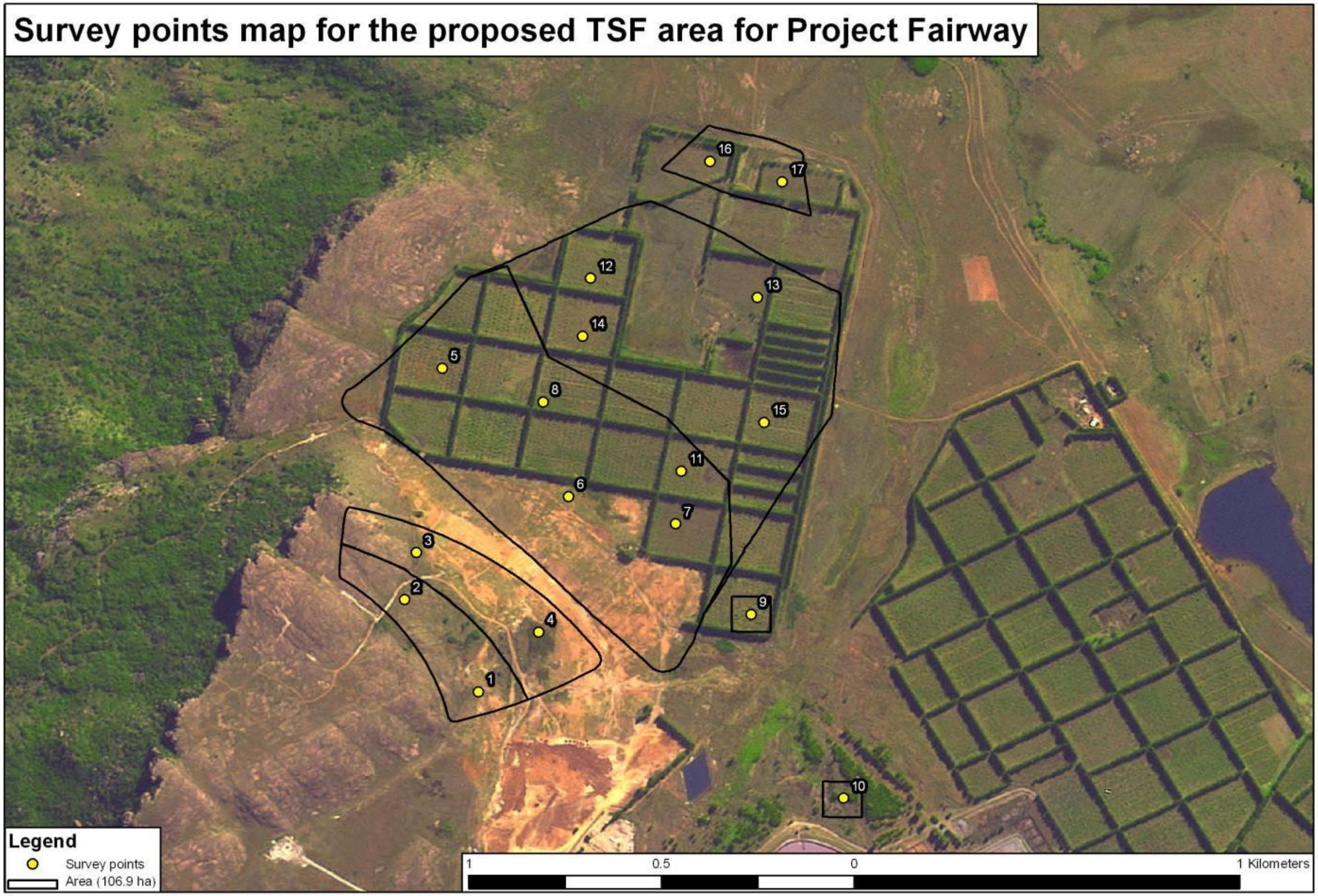

Figure 4: Survey points map for the proposed TSF area

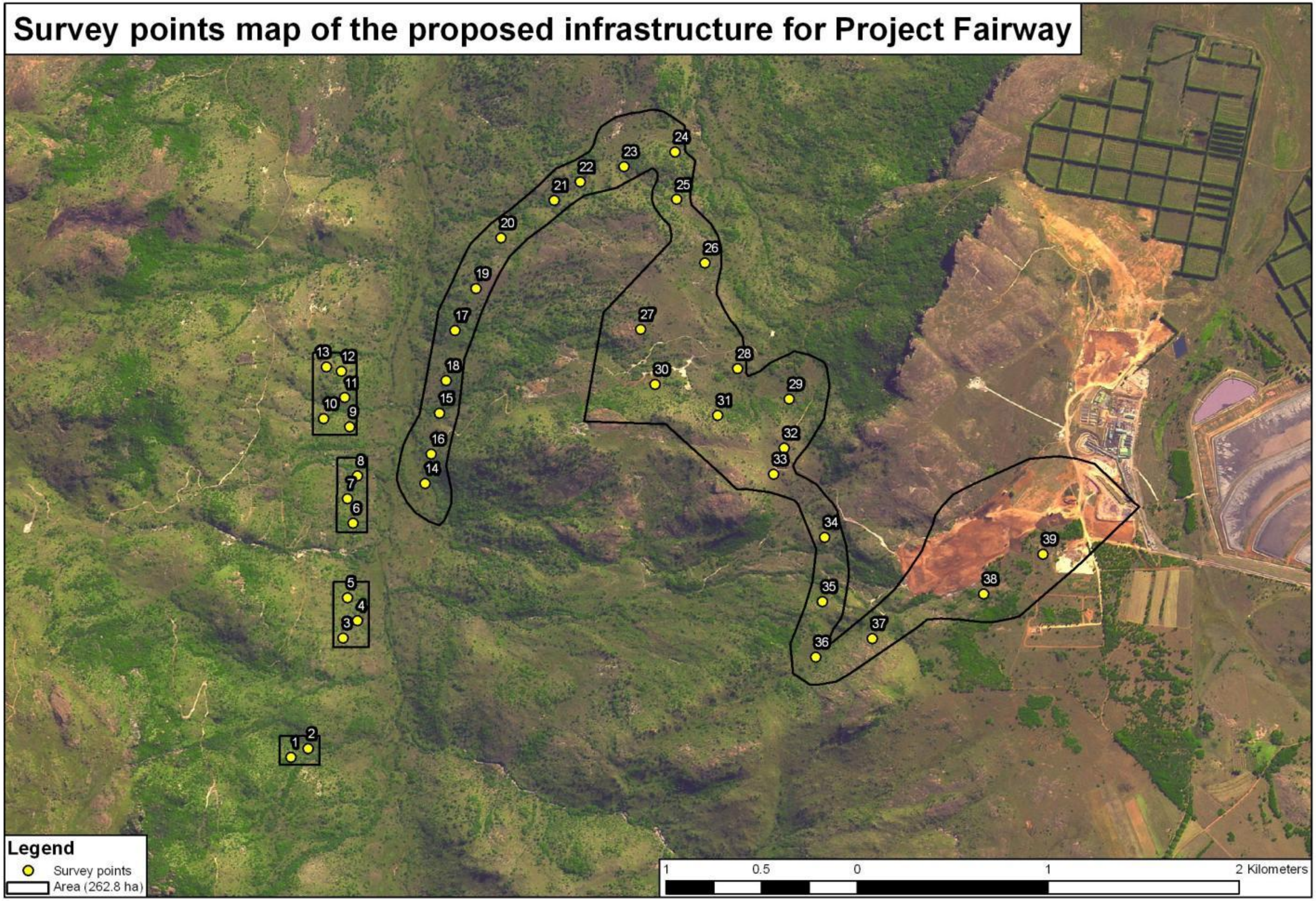

Figure 5: Survey points map of the proposed infrastructure areas of Project Fairway

9.2 Soil classification

9.2.1 TSF area

Five different soil forms are present in the proposed TSF area that can be divided into two groups i.e. soil with high agricultural potential and hydromorphic (wetland) soils. Although the current footprint of the TSF is planned to be slightly smaller, it was considered beneficial to include a slightly larger area to accommodate an additional area that might be affected. The high agricultural potential soils include soils of the Hutton, Shortlands and Clovelly forms while wetland soils consist of a mixture of Kroonstad and Katspruit forms. The areas for these soil forms are summarised in Table 9.

Table 2: Summary of soil forms in the TSF area

SUMMARY OF SOIL FORMS IDENTIFIED FOR THE TSF AREA OF PROJECT FAIRWAY			
SOIL FORM	**MAP COLOUR**	**AREA (ha)**	**% OF FOOTPRINT AREA (%)**
Hutton		12.8	12.0
Shortlands		75.5	70.8
Clovelly		11.9	11.2
Katspruit/Kroonstad		6.5	6.1
TOTALS		106.7	100.0

9.2.1.1 Soil with high agricultural potential

Hutton form:

The Hutton soil form (27 ha or 18.2% of the study site) consist of an orthic A horizon on a red apedal B horizon overlying unspecified material. All Hutton profiles are not shallower than 800mm and some are deeper than 1200mm with no restrictive layers and are structureless or have very weakly developed structure. Hutton soils with no restrictions shallower than 500mm are generally good for crop production.

The red apedal B1-horizon has more or less uniform "red" soil colours in both the moist and dry states and has weak structure or is structureless in the moist state. This horizon develops in well-drained, oxidizing environments that produce coatings of iron oxides (hematite) on the soil particles, causing the red colours of the horizon.

The red apedal horizon is per definition non-calcareous within 1500mm of the soil surface, but may contain small lime nodules. The range of red colors that is a key identification tool in differentiating between a red apedal and yellow-brown apedal is defined by the Soil Classification Working Group Book, 1991. Some of the defining red soil colors identified on the sites are bleached (10R 6/4 and 10R6/6), while some are bright red (2.5YR 4/8).

The red apedal soils have generally developed on meta-sandstone/quartzite parent material, which has a low content of weatherable minerals and thus low clay forming potential. These soils have occasionally also developed on ferricrete parent material, which has a moderate content of weatherable minerals and thus a moderate clay-forming potential. The clay mineral suites present a mixture of non-swelling 1:1 types, and swelling 2:1 types (hence the variation of structural development from weak blocky to apedal).

Textures are coarse to medium sand to sandy-loam in the topsoil and medium to fine sandy-loam in the subsoil. Structure is weak blocky (dominant) or apedal in all horizons.

The high quality orthic A and red apedal B-horizons make it a suitable soil form for annual crop production (good rooting medium) and use as 'topsoil', having favorable structure (weak blocky to apedal) and consistence (slightly firm to friable). This soil form is ideal for crop production purposes of grains, fruits and vegetables.

Shortlands form

The Shortlands soil form (27 ha or 18.2% of the study site) consist of an orthic A horizon on a red structured B1 horizon. The structure of the B1 horizon is more strongly developed than that of the red apedal B horizon present in the Hutton soil form. The transition between the A and B1 horizon is gradual and not abrupt as is often the case with underlying cutanic horizons. The pedality of this horizon is the result of a sufficient amount of clay and the presence of 2:1 clay minerals. The Shortland soil forms identified on this site is deeper than 600mm.

The Shortlands soil form also has high agricultural production potential and although it is moderately structured, it is not a physical barrier for penetration by crop roots.

Clovelly form

Soils of the Clovelly soil form were found on a total of 25 ha (or 16.9% of the study site). Texture is fine sandy to sandy-loam to loam for all horizons and profiles were not shallower than 600mm and some were deeper than 1500mm. The high to moderate quality orthic A and yellow-brown apedal B-horizons are suitable materials for annual cropping (good rooting medium) and use as 'topsoil', having favourable structure (apedal) and consistence (friable).

The Clovelly form has an orthic A horizon overlying a yellow-brown apedal B1-horizon with unspecified material underneath the apedal horizon. The unspecified material does not have any signs of wetness. The orthic A-horizon is either between 100mm and 300mm deep or absent due to earlier crop cultivation practices.

The yellow-brown apedal horizon has more or less uniform "yellow-brown" soil colours in both the moist and dry states and has weakly developed blocky structure or is structureless in the moist state. This horizon develops in a well-drained oxidizing environment, but with different mineral-chemical coatings (goethite) on soil particles than those of the red apedal horizon.

9.2.1.2 Hydromorphic soils (30 ha or 20.3% of the study site)

Katspruit form

The Katspruit soil form comprises an orthic A-horizon overlying a G-horizon with the orthic horizon between 15 and 30 cm deep and the G-horizon thicker than 100 cm. G-horizons develop when water saturation for long periods gives rise to gleying with the reduction of ferric oxides and hydrated oxides. The G-horizon is dominated by grey, low chroma colours, usually with marked clay illuviation. These soils occur in the seasonal to permanent zone of wetlands.

Kroonstad form

The Kroonstad form differs from the Katspruit form in that the G-horizon is overlain by an E horizon that occurs underneath the orthic A horizon. This soil form also indicates seasonal to permanent wetland zones.

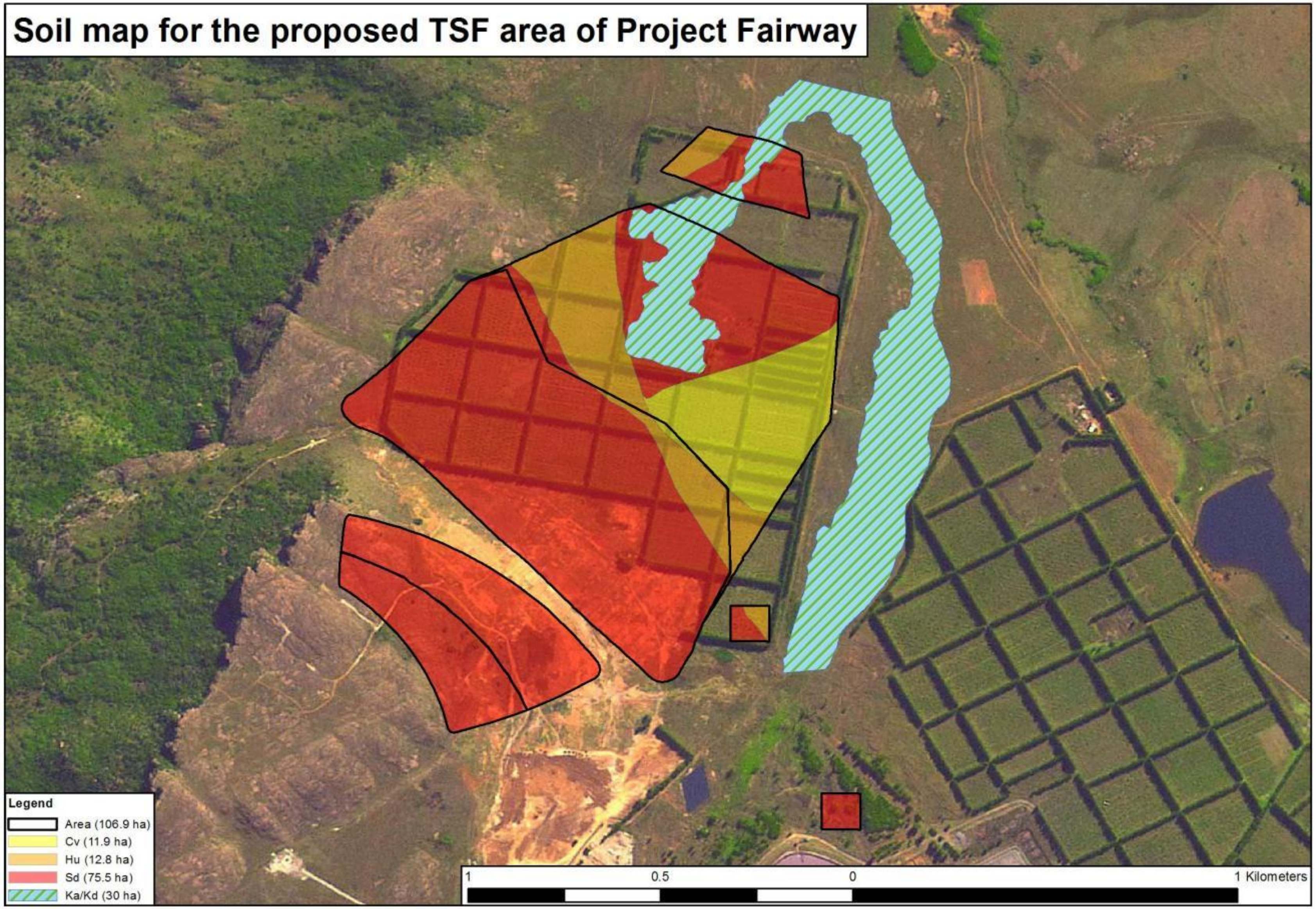

Figure 6: Soil map for the proposed TSF area of Project Fairway

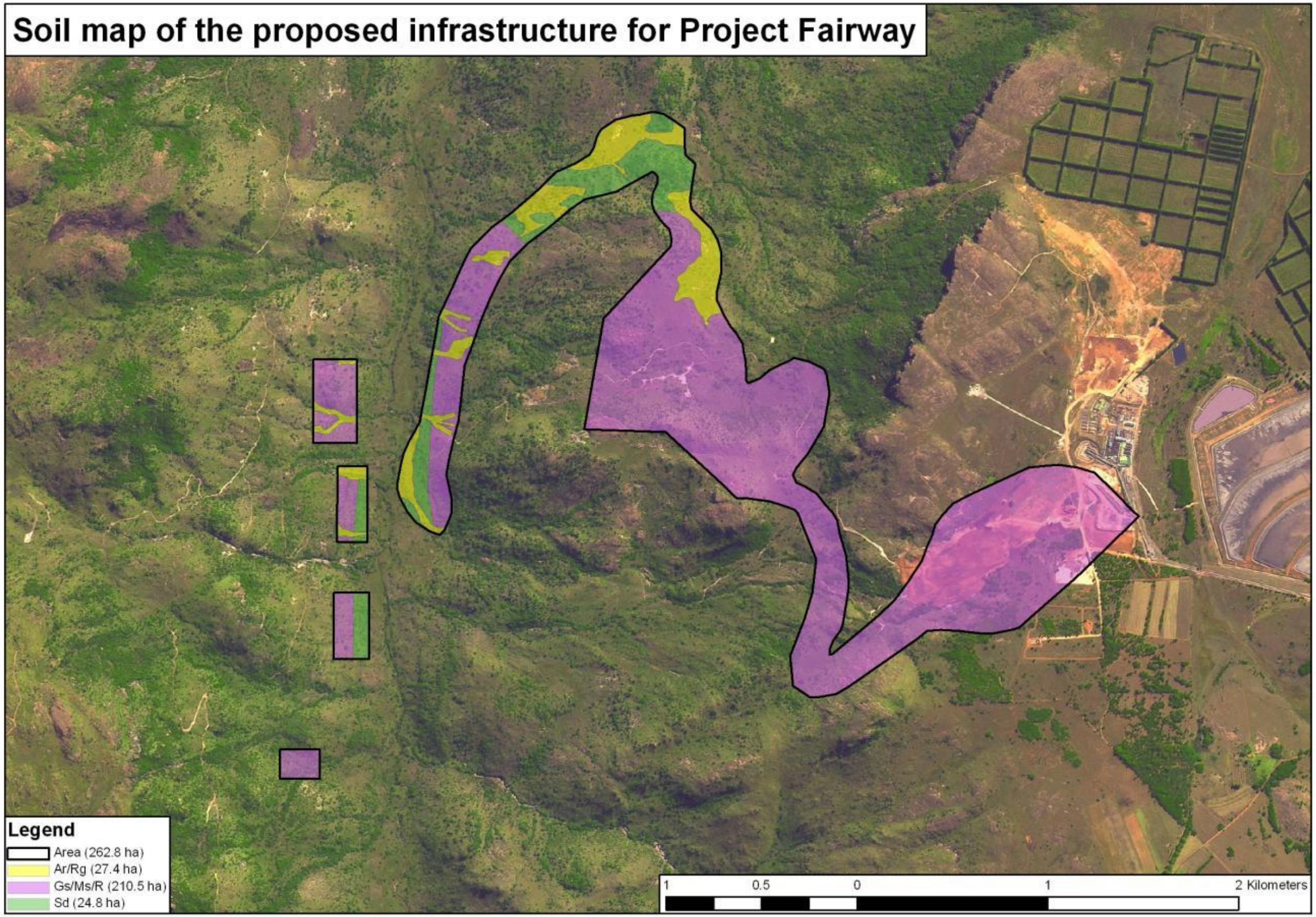

Figure 7: Soil map for the proposed infrastructure areas of Project Fairway

9.2.2 Infrastructure area

Five different soil forms are present in the proposed infrastructure area that can be divided into three broad groups i.e. shallow rocky soils (Glenrosa, Mispah and rocky outcrops), shallow to medium-deep structured soils (Shortlands soil form) that were identified in areas with plateaus or valley bottoms and hydromorphic (wetland) soils (Arcadia and Rensburg soils). Although the current footprint of the infrastructure will be much smaller, it was considered beneficial to include an additional area for mapping purposes and future use, should the footprint expand.

Table 3: Summary of soil forms in the infrastructure area

SUMMARY OF SOIL FORMS IDENTIFIED FOR THE INFRASTRUCTURE AREA OF PROJECT FAIRWAY			
SOIL FORM	**MAP COLOUR**	**AREA (ha)**	**% OF STUDY AREA (%)**
Glenrosa/Mispah/Rock		210.5	80.1
Shortlands		24.8	9.4
Arcadia/Rensburg		27.4	10.4
TOTALS		262.7	100.0

9.2.2.1 Shallow, rocky soils

This group consists of three soil forms: Mispah (Ms), Glenrosa (Gs) and rocky outcrops. 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 clay-loam texture, while topsoil structure ranges from apedal to weakly blocky and the profiles are very shallow (as shallow as 0.15m of soil on a rocky layer).

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 poor topsoils are not ideal for rehabilitation purposes for they are too shallow and/or too rocky to strip, this topsoil being lost unless it can be recovered by a screening process (recommended). Topsoil stripping and stockpiling of the 'shallow' soils should only be attempted where the surface is not too rocky.

9.2.2.2 Shallow to medium-deep structured soils

The Shortlands soil form (116.3 ha or 13.9% of the study site) consist of an orthic A horizon on a red structured B1 horizon. This soil form has the same characteristics as described for the TSF area, however, the profiles that occur in the infrastructure area range between 250mm and 500mm deep and small rocks are present. The depth of these soil profiles are restricted by rock or weathered rock layers.

9.2.2.3 Hydromorphic soils

The hydromorphic soils consist of the vertic soils of the Rensburg and Arcadia forms. Although not all Rensburg and Arcadia soils can be classified as wetland soils, these soils showed signs of wetness and are associated with drainage lines on the site for the proposed infrastructure.

These soil forms were found on 87.5 ha (10.5% of study area). The vertic soils have A-horizons that have both high clay content and a predominance of smectitic clay mineral possess the capacity to swell and shrink 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.

Swell-shrink potential is manifested typically by the formation of conspicuous vertical cracks in the dry state and the presence, at some depth, of slickensides (polished or grooved glide planes produced by internal movement). However, the presence of these planes is apparently also a function of vertical thickness, being dependent on the total volume of the material which swells and shrinks.

9.3 *Soil chemical characteristics and soil fertility*

The chemical soil analysis of soil sampled from the survey site is discussed below.

9.3.1 Soil pH

Soil pH is an indicator of soil acidity and alkalinity. Most soils have a pH in the range of 4 to 10. The pH of a particular soil, such as 5 or 8, reflects a certain chemical and mineralogical environment in that soil, and thus the pH is of great importance to plant roots and microbial activity. For these reasons soil pH is one of the most important factors affecting soil fertility.

Chemically, the pH is an expression of the H ion activity (H+) or H ion concentration. Many parent materials and young soils are alkaline, but old and intensely weathered soils are typically acid. This change in soil pH is related to and parallels the changes in the mineralogical and chemical properties that occur over time. Descriptive terms commonly associated with certain ranges in soil pH are presented in **Table 11**.

Table 4: Terminology associated with pH

pH range	Terminology
<4,5	Extremely acid
4,5 – 5,0	Very strongly acid
5,1 – 5,5	Strongly acid
5,6 – 6,0	Medium acid
6,1 – 6,5	Slightly acid
6,6 – 7,3	Neutral
7,4 – 7,8	Mildly alkaline
7,9 – 8,4	Moderately alkaline
8,5 – 9,0	Strongly alkaline
>9,0	Very strongly alkaline

The soil pH has a direct influence on plant growth in a number of ways:

- through the direct effect of the hydrogen ion concentration on nutrient uptake;
- indirectly through the effect on trace nutrient availability; and by the
- mobilisation of toxic ions such as aluminium and manganese, which restrict plant growth.

The pH(H_2O) of the analyzed soil samples range between 5.3 and 5.6. According to Table 5 the soils found on the sites can be described as strongly acid. Should the entire site have consisted of soils with high agricultural potential, it would have required the addition of agricultural lime to improve crop yield and plant performance.

9.3.2 Other soil elements

Soil fertility describes the potential of land for successful crop production. Soil fertility can usually be improved by the addition of chemical fertilizers. However, with sharp increases in the price of these fertilizers and the negative environmental impact that these chemicals have on groundwater and surface water runoff quality it is becoming increasingly important to manage the inherent soil fertility correctly. This fertility is the combined result of the exchangeable bases namely Ca (calcium), Mg (magnesium), K (potassium) and Na (sodium).

Potassium (K) plays many essential roles in plants. It is extremely mobile within the plant and helps regulate the opening and closing of stomata in the leaves as well as the uptake of water by root cells. It is also essential for photosynthesis, protein synthesis and starch formation. Potassium levels are generally deficient ranging from 19 to 93 mg/kg. Potassium uptake by plants is further decreased by the dominance of the cation complex by high calcium and magnesium levels.

The phosphorus (P) level measured is 2 mg/kg. Although this seems very low for a crop production situation, it is normal for South African veld conditions. The cation chemistry (Ca, Mg, K, Na) is typical that of the soil forms in the area of the proposed project. Very high levels of calcium (1413 to 2678 mg/kg) and magnesium (437 and 706 mg/kg) will suppress low levels of potassium (19 – 93 mg/kg) during nutrient uptake by plants.

COMPANY:	TERRA - AFRICA	NAME:	FAIRWAYS - EVEREST PLATINUM MINE	Building H1
ADDRESS:		FARM:		AECI-site
ADDRESS:		DISTRICT:		De Beers Avenue
TEL/FAX:		DATE:	21-Nov-11	Somerset West
REF:	218139	REP:		Tel: (021) 852 7899

Lab Nr.	Ref.	Camp	pH	P	K	Ca	Mg	Na	Ca	Mg	K	Na	Ohm	C
			KCl	Bray 1	Amm Acetate				%					WB
				mg/kg	mg/kg									%
112945	1	FAIRWAY 01 - TOPSOIL	5.4	2	29	2678	706	16	69.3	30.0	0.4	0.4	860	0.88
112946	2	FAIRWAY 02 - TOPSOIL	5.3	2	31	1413	447	13	65.0	33.7	0.7	0.5	2000	1.12
112947	3	FAIRWAY 03 - SUBSOIL	5.4	2	19	1460	484	17	64.1	34.9	0.4	0.6	2050	0.48
112948	4	FAIRWAY 04 - TOPSOIL	5.4	2	95	2137	437	14	73.3	24.6	1.7	0.4	1080	1.84
112949	5	FAIRWAY 05 - TOPSOIL	5.5	2	93	1935	456	7	70.7	27.3	1.7	0.2	1700	1.60
112950	6	FAIRWAY 06 - SUBSOIL	5.6	2	27	1617	472	12	67.0	32.0	0.6	0.4	1800	0.88

Lab Nr.	Ref.	Camp	Ca:Mg	(Ca+Mg)/K	Mg:K	S-Value	T-Value	Base Sat	Cu	Zn	Mn	Fe
			Norms			cmol(+)/kg	cmol(+)/kg	%	0.1M HCl			
			1.5 - 4.5	10 - 20	3 - 4				mg/kg			
112945	1	FAIRWAY 01 - TOPSOIL	2.3	260.0	78.5	19.3	19.3	100.00	1.23	0.72	20.10	13.30
112946	2	FAIRWAY 02 - TOPSOIL	1.9	133.4	45.6	10.9	10.9	100.00	1.33	0.73	20.50	9.50
112947	3	FAIRWAY 03 - SUBSOIL	1.8	229.2	80.7	11.4	11.4	100.00	1.57	0.60	12.80	12.90
112948	4	FAIRWAY 04 - TOPSOIL	3.0	58.6	14.7	14.6	14.6	100.00	1.07	1.00	19.80	3.00
112949	5	FAIRWAY 05 - TOPSOIL	2.6	56.4	15.7	13.7	13.7	100.00	0.95	1.28	24.80	6.70
112950	6	FAIRWAY 06 - SUBSOIL	2.1	173.0	56.0	12.1	12.1	100.00	1.52	0.64	20.40	19.50

Figure 8: Laboratory analysis results for Project Fairway

10. LAND CAPABILITY

10.1. Introduction and methodology

Land capability classes were determined using the guidelines outlined in Section 7 of The Chamber of Mines Handbook of Guidelines for Environmental Protection (Volume 3, 1981), a summary of which follows (Table 8). The Chamber of Mines pre-mining land capability system was utilised, given that this is the dominant capability class classification system utilized in the mining and industrial fields.

Table 5: Pre-Mining Land Capability Requirements

Criteria for Wetland	➢ Land with organic soils or ➢ A horizon that is gleyed throughout more than 50 % of its volume and is significantly thick, occurring within 750mm of the surface.
Criteria for Arable Land	➢ Land, which does not qualify as a wetland, ➢ The soil is readily permeable to the roots of common cultivated plants to a depth of 750mm, ➢ The soil has a pH value of between 4,0 and 8.4, ➢ The soil has a low salinity and SAR, ➢ The soil has a permeability of at least 1,5-mm per hour in the upper 500-mm of soil ➢ The soil has less than 10 % (by volume) rocks or pedocrete fragments larger than 100-mm in diameter in the upper 750-mm, ➢ Has a slope (in %) and erodibility factor (K) such that their product is <2.0, ➢ Occurs under a climatic regime, which facilitates crop yields that are at least equal to the current national average for these crops, or is currently being irrigated successfully.
Criteria for Grazing Land	➢ Land, which does not qualify as wetland or arable land, ➢ Has soil, or soil-like material, permeable to roots of native plants, that is more than 250-mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100-mm, ➢ Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants, utilizable by domesticated livestock or game animals on a commercial basis.
Criteria for Wilderness Land	• Land, which does not qualify as wetland, arable land or grazing land.

10.2. TSF area

Following the classification system above, the soil and land types identified in the TSF study area could be classified into two land capability classes (**Figure 9**) i.e. land with arable land capability (the Hutton, Shortlands and Clovelly soil forms) as well as land with wetland land capability (Kroonstad/Katspruit forms). The areas with arable land capability (100.3ha) are suitable for both irrigated and dryland crop production. The areas with wetland land capability (6.5ha) are suitable for conservation and grazing purposes. However, overgrazing should be avoided that will result in trampling of wetland areas.

10.3. Fairway infrastructure area

The infrastructure area can be divided into land with three different land capabilities (**Figure 10**). The area is dominated by wilderness land capability (210.5ha) due to the very shallow, rocky nature of soil forms present as well as the steep slopes. The main use of this land capability should be conservation due to the extreme biodiversity that occurs in the area (as well as it being a centre of floristic endemism). The slightly deeper soil profiles in the valley bottoms on plateaus can be classified as land with grazing land capability (24.8 ha). These areas are more suitable for cattle and game farming. Areas with wetland land capability (27.4ha) are mostly drainage lines and marshy areas. These areas are suitable for conservation and light grazing.

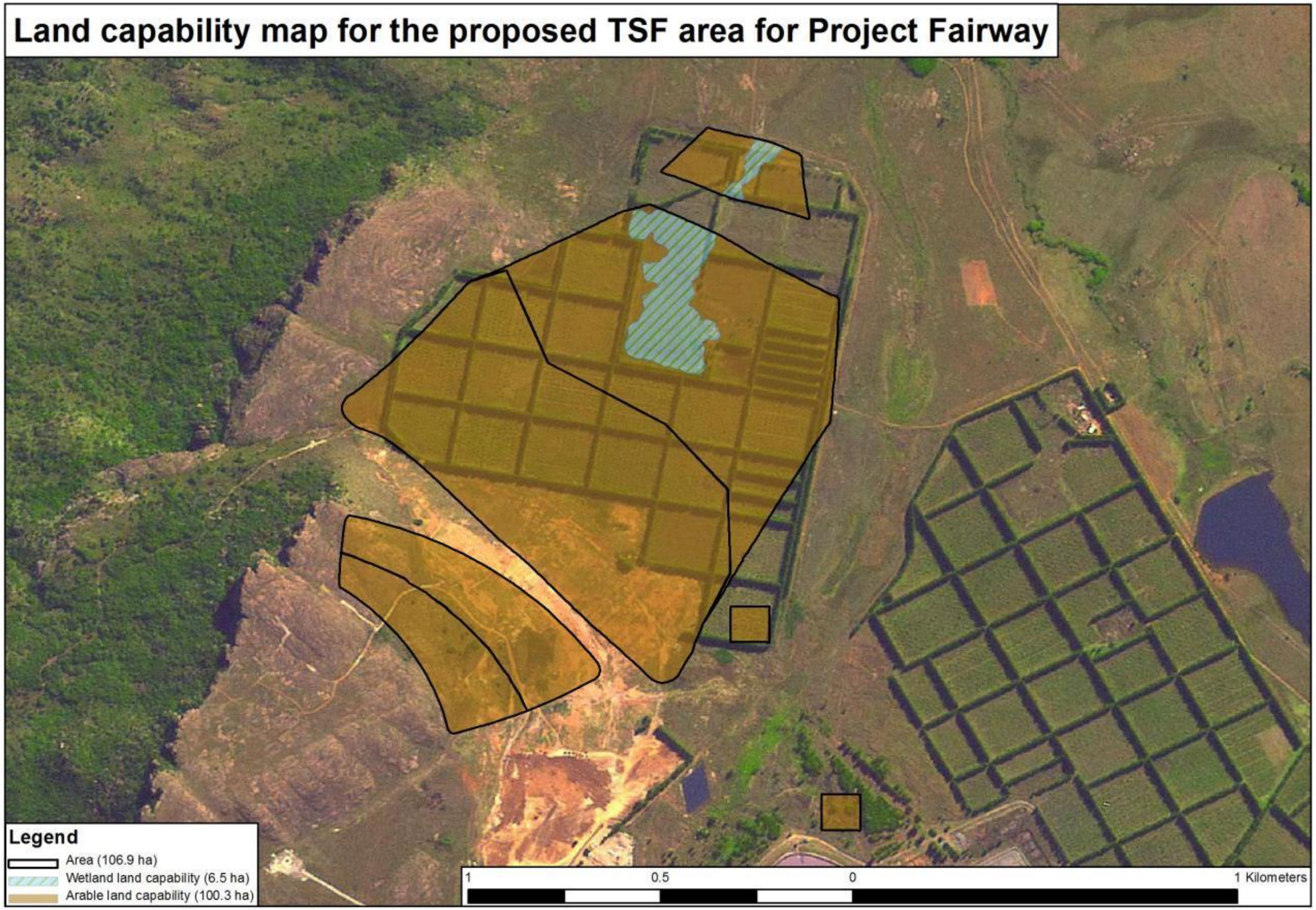

Figure 9: Land capability map for the proposed TSF area of Project Fairway

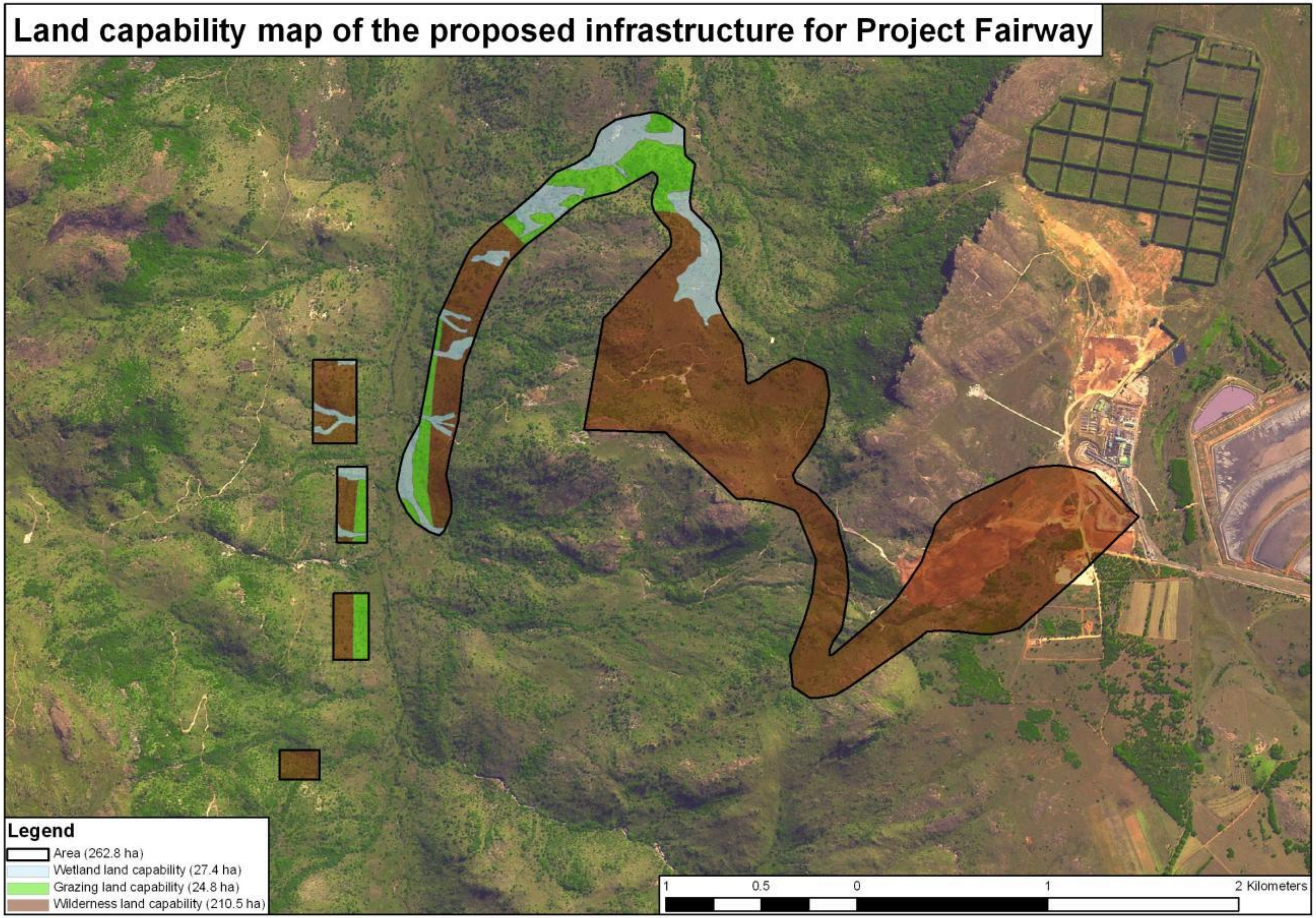

Figure 10: Land capability map for the proposed infrastructure area of Project Fairway

11. ENVIRONMENTAL IMPACTS

11.1 Background information

For the impact assessment, all the following phases of the project cycle were considered for potential impacts on soil and land capability. Below is a description of each of the activities per phase that may result in soil impacts:

Construction phase:

- Establishment of proposed box-cuts from surface;
- Establishment of the valley access road;
- Selective clearing of vegetation in areas designated for surface infrastructure;
- Stripping and stockpiling topsoil and sub-soil;
- Digging of foundations and trenches.
- Preparation of residue disposal areas;
- Delivery of materials (steel and equipment) as well as transport of construction personnel.
- Blasting (where required);
- General building/construction activities.

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Operational phase:

- Daily traffic on the new valley access road
- Construction of ventilation shafts as mining progresses
- Operations at new tailings storage facility
- Daily mining activities in different areas of the proposed Project Fairway such as the proposed new building complex at the Waterfall Box-cut that includes a gate house, workshop, office complex, substation, MCC and transformer bay, a fuel and lubrication storage facility, wash bay, store, and explosive off-loading facility
- Activities at and around all of the box-cuts including sewage treatment at the sewage treatment facility

Closure:

- Removal of infrastructure from soil surfaces
- Removal of topsoil from stockpiles and using it to re-establish vegetation in disturbed areas
- Increased traffic on valley road to transport waste materials out of the valley as well as with construction vehicles to do rehabilitation

The following impacts on soil and land capability are anticipated for the project:

- Soil erosion due to steep slopes and vegetation clearance
- Topsoil degradation
- Soil compaction due to regular heavy vehicle transport
- Chemical soil pollution as a result of potential spillage of petroleum hydrocarbons and other soil pollutants
- Loss of agricultural potential and arable land capability in TSF area
- Loss of wetland land capability in TSF and infrastructure areas
- Loss of grazing and wilderness land capability in the infrastructure areas

11.2 Impact assessment for the anticipated impacts

11.2.1 Impact: Soil erosion

Phase of project cycle:

During the construction phase, soil is susceptible to erosion because the natural vegetation will be cleared before construction takes place in both the infrastructure and TSF areas. During the operational phase, topsoil stockpiles and gravel roads will still be susceptible to erosion while soil surfaces with infrastructure such as buildings will not be exposed to erosion any longer. With the closure phase, soil surfaces are in the process of being replanted with indigenous vegetation and until vegetation cover has established successfully, surfaces are still exposed to potential soil erosion.

Environmental significance of soil erosion:

Soil will be prone to erosion where vegetation has been removed. The current vegetation layer protects the topsoil (a very shallow layer for a large portion of the site) and once removed, will result in wind erosion and erosion by the impact of water flow, especially during the rainy season.

Significance of unmitigated soil erosion impact:

Erosion will have low impact on a spatial scale as it will be localised within the site boundary. The duration of erosion once it has taken place is long term for it is very hard to recover sediment that has been transported away from its position in the landscape. It is considered to have high severity as soil erosion results in loss of the growth medium for the indigenous vegetation that is an essential component the ecosystem of the proposed site.

Significance of mitigated soil erosion impact:

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. The establishment of vegetation on stockpiles and management of storm water will improve the severity moderately to be within an acceptable level. With mitigation measures the duration of the impact is reversible over time.

Possible mitigation measures:

- Stripping of topsoil should not be conducted earlier than required (maintain grass cover for as long as possible) in order to prevent the erosion (wind and water) of organic matter, clay and silt.
- Stripped soils should be stockpiled as a berm upslope (majority) and surrounding the disturbed area.
- Soil stockpiles must be sampled, ameliorated (if necessary) and re-vegetated as soon after construction as possible. This is in order to limit raindrop and wind energy, as well as to slow and trap runoff, thereby reducing soil erosion. Grassland and shrub species indigenous to the area are preferred, given both their hardy nature as well as their lower maintenance requirements. This is highly recommended in order to maintain the natural biological soil life associated with the indigenous vegetation.

- Although it is recommended that the soils stripped for leveling purposes must be stockpiled as a berm along the entire length of haul roads (upslope), it may be difficult to implement along the valley road as the steep slopes and rocky nature of the environment makes it very difficult to find level areas to stockpile.
- Erosion control measures such as intercept drains and toe berms must be constructed where necessary.
- Gravel roads must be well drained in order to limit soil erosion.
- 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).
- The gravel haul road drainage system and surface must be well maintained in order to limit soil erosion

11.2.2 Impact: Degradation of topsoil layer

Phase of project cycle:

The sterilization of the fertile topsoil layer is only considered to be an impact during the operational phase and not during construction and closure phases.

Environmental significance:

During the construction phase, topsoil is stripped and stockpiled for almost all proposed activities including construction of the tailings storage facilities, main road into the valley, box cuts as well as where vent shafts will be constructed. The reason for stripping topsoil is to have soil material available for rehabilitation purposes during ongoing rehabilitation and the closure phases.

The most critical and important part of the soil is the uppermost 20-cm as this is the repository for seeds, tubers, bulbs etc. Under natural conditions most grass seed remains viable for only about 1 year (reproductive seedbank life), with only few species having seed that can survive for up to 2 - 3 years. Under stockpile conditions it is probable that the seedbank life will be shorter than under natural conditions.

The stockpiles will remain more than six months during which the organic carbon content of the soil will decompose without availability of new carbon sources from dead plant roots and leave litter. This will result in the soil carbon cycle will be disturbed. The disturbance of the soil nutrient cycle will lead to imbalances in the soil microbial population that form an integral part of the soil-plant ecosystem of the area.

<u>Significance of unmitigated degradation of topsoil layer:</u>

Degradation of topsoil will have low impact on a spatial scale as it will be localised within the site boundary. The duration of the topsoil once it has taken place is long term for it will last beyond closure. It is considered to have high severity as degradation results in the loss of the properties of the growth medium that supports the indigenous vegetation.

<u>Significance of mitigated impact on degradation of topsoil:</u>

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. The establishment of vegetation on stockpiles during the operational phase, management of storm water and using of topsoil to establish nursery plants, will improve the severity moderately. With mitigation measures the duration of the impact is reversible over time.

<u>Possible mitigation measures:</u>

- Soil stockpiles must be sampled, ameliorated (if necessary) and re-vegetated as soon after construction as possible. This is in order to limit raindrop and wind energy, as well as to slow and trap runoff, thereby reducing soil erosion. Grassland and shrub species indigenous to the area are preferred, given both their hardy nature as well as their lower maintenance requirements. This is highly recommended in order to maintain the natural biological soil life associated with the indigenous vegetation.
- Topsoil should be used shortly after stripping to fill nursery bags that will be used to re-establish indigenous vegetation in a proposed nursery at the mine. This will ensure that beneficial micro-organisms associated with the indigenous plants remain active in the soil and will re-establish populations in the landscape once it is transplanted during rehabilitation.

11.2.3 Impact: Soil compaction

Phase of project cycle:

During the construction phase, soil is susceptible to compaction from heavy construction vehicles when soil is stripped and stockpiled. During the operational phase, soil compaction increases as the weight of the stockpiles results in further compaction as well as the constant traffic on the haul roads. With the closure phase, soil is again compacted as construction vehicles move up and down to remove infrastructure and move topsoil to areas for rehabilitation purposes.

Environmental significance:

Soil compaction will take place due to unnatural load and increase traffic by heavy construction vehicles in the area will change soil structure. Soil compaction generally reduces the amount of water that plants can take up. This is because compaction crushes many of the macropores and large micropores into smaller pores, and the bulk density increases. As the clay particles are forced closer together, soil strength may increase beyond about 2000 kPa, the level considered to limit root penetration. Compaction also results in aggravation of run-off erosion as compaction reduces the water infiltration rate.

Significance of unmitigated soil compaction impact:

Soil compaction will have low impact on a spatial scale as it will be localised within the site boundary. The duration of compaction once it has taken place is long term for it is very hard to prevent soil compaction on a mining site due to the nature of the activities. It is considered to have high severity as soil compaction will alter the physical properties such as water infiltration rate that it may be difficult for plants to re-establish themselves in these soils.

Significance of mitigated soil compaction impact:

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. Mitigation measures are anticipated to have a low positive impact as it is likely to result in only a minor improvement. The duration of this impact, even with mitigation measures, is considered to be permanent.

11.2.4 Impact: Chemical soil pollution

Phase of project cycle:

During the construction phase, chemical soil pollution can result from oil and fuel leakages from construction vehicles. During the operational phase, accidental spillages or leakages from the tailings storage facility can result in toxic substances entering groundwater resources and soil ecosystems. Spillages from fuel storage units and leakages from construction vehicles can also result in chemical pollution. With the closure phase, soil surfaces are exposed to chemical soil pollution when stored fuel is transported off-site and by leakages from vehicles.

Environmental significance:

The use of vehicles can result in oil and fuel spills on site as well as waste generation by construction and construction workers and the proposed workshop can result in possible chemical soil pollution. Spillages from fuel storage units as well as leakages from the TSF area can further result in chemical soil pollution. Tailings that will be stored at the TSF is a high-volume waste that can contain harmful quantities of toxic substances, including arsenic, lead, cadmium, chromium and nickel.

These soil contaminants can have significant deleterious consequences for ecosystems. There are radical soil chemistry changes which can arise from the presence of many hazardous chemicals even at low concentration of the contaminant species. These changes can manifest in the alteration of metabolism of endemic microorganisms and arthropods resident in a given soil environment. The result can be virtual eradication of some of the primary food chain, which in turn could have major consequences for predator or consumer species. Even if the chemical effect on lower life forms is small, the lower pyramid levels of the food chain may ingest pollutant chemicals, which normally become more concentrated for each consuming rung of the food chain.

Contaminated or polluted soil can also directly affect human health through direct contact with soil or via the infiltration of soil contamination into groundwater aquifers used for human consumption, sometimes in areas apparently far removed from any apparent source of above ground contamination.

Significance of unmitigated chemical soil pollution:

Chemical soil pollution will have medium impact on a spatial scale as it may stretch beyond the site boundary once it entered groundwater resources. The duration of pollution once it has taken place is long term, depending on the nature and properties of the specific pollutant. It is considered to have high severity as soil chemical pollution may have a negative impact on ecosystem and/or human health.

Significance of mitigated chemical soil pollution:

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. Mitigation measures are anticipated to have a high positive impact as it is likely to result in only a major improvement. The duration of this impact, should it be properly mitigated, is considered to be either quickly reversible or reversible over time, depending on the nature and volume of the pollutant spillage.

Possible mitigation measures:

- Any chemical spillage should be cleaned up immediately and treated or disposed by contractors who specialize in hazardous waste.
- If financially viable, the TSF should be lined with impermeable lining.
- An intercept drain should be constructed upslope of construction and operational areas, in order to re-direct clean water away to avoid soil chemical pollution to clean groundwater resources.
- An intercept drain should possibly be constructed downslope of polluted areas, in order to drain potentially polluted water into a pollution control dam.
- Drains and intercept drains should be maintained to ensure that it continue to redirect clean water away from the polluted areas.

- Conduct proper chemical waste management to avoid spillage of chemicals during all the phases of the project cycle.

11.2.5 Impact: Loss of arable land capability

Phase of project cycle:

During the construction phase of the TSF, the arable land capability and the associated agricultural potential of the land will be lost once the topsoil has been stripped. There will be no additional impacts during the operational and closure phases. Due to the permanent nature of the TSF, it is not anticipated that closure will have any positive impact on the arable land capability of the proposed project site.

Environmental significance:

Once constructed, the TSF will become a permanent feature and remain in perpetuity. Therefore, the 100.3 ha of land with arable land capability will be covered permanently and will not have the potential for crop production any longer. It is therefore not possible to mitigate the impact on the proposed site but a practical mitigation measure will be to make other areas with arable land capability on nearby property available to a research institution for research on the potential of fruit production in the area.

Significance of unmitigated loss of arable land capability:

Loss of arable land capability will have low impact on a spatial scale as it will be localised within the site boundary. The duration of this impact is high for it is permanent. It has high severity for the soil resource will be lost completely.

Significance of mitigation measures:

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. Mitigation measures are anticipated to have a high positive impact as it is likely to result in only a substantial improvement (see detail explanation of mitigation measures). The duration of this impact, although mitigated by off-site mitigation, is considered to be permanent.

Possible mitigation measures:

Due to the permanent nature of tailing storage facilities, it will not be possible to mitigate the impact on arable land capability on the proposed site. However, it is highly recommended as a mitigation measure that another portion of land with the same land capability and climate characteristics be made available by the mine to a research facility for trials on the viability and productivity of deciduous fruit in this region. It is suggested that the Department of Plant Production and Soil Science of the University of Pretoria be considered for these trials as they previously conducted trials on these crops (kiwi fruit, almonds and peaches) before the section with the kiwi fruit orchards of the experimental farm was used for the construction of buildings. This mitigation measure will make a valuable contribution to agricultural research in South Africa.

11.2.6 Impact: Loss of grazing and wilderness land capability

Phase of project cycle:

During the construction phase of the infrastructure areas, the grazing and wilderness land capability of these areas will be lost once the topsoil has been stripped. There will be no additional impacts during the operational phase and these areas will be re-vegetated during the closure phase.

Environmental significance:

Once stripping and stockpiling commences for the construction phase, the grazing and wilderness land capability of these areas will be lost due to the removal of the vegetation and adding of mining infrastructure. It is the closure objective to rehabilitate the area to such an extent that the grazing and wilderness land capability is restored.

Significance of unmitigated loss of grazing and wilderness land capability:

Loss of grazing and wilderness land capability will have low impact on a spatial scale as it will be localised within the site boundary. The duration of this impact is medium for it is reversible over time. It will have medium severity as it will result in measurable deterioration.

Significance of mitigation measures:

With proper mitigation measures as recommended below, it is anticipated that the spatial scale of the impact will still be low and localised within the site boundary. Mitigation measures are anticipated to have a medium positive impact as it is likely to result in a moderate improvement. The duration of this impact, although mitigated by off-site mitigation, is considered to be medium and reversible over time.

Possible mitigation measures:

The land capability of the topsoil stockpiles should be maintained as wilderness by establishing natural vegetation on them to prevent soil erosion and to maintain the soil ecosystem (micro-organisms and nutrient cycles).

Once the closure phase has started or when areas are no longer used for mining activities, the landscape should be rehabilitated to its original land capability by establishing indigenous vegetation that was present before the proposed project commenced.

11.2.7 Impact: Loss of wetland land capability

Phase of project cycle:

During the construction phase of the TSF, the wetland land capability and the associated functionality of the soil forms associated with this land capability will be lost once the topsoil has been stripped. There will be no additional impacts during the operational and closure phases. Due to the permanent nature of the TSF, it is not anticipated that closure will have any positive impact on the wetland land capability of the proposed project site.

Environmental significance:

Once constructed, the TSF will become a permanent feature and remain in perpetuity. Therefore, the 6.5 ha of land with wetland land capability will be covered permanently with tailings. The hydromorphic soil forms in this area will function as wetland soils anymore with the water purification and water storage properties associated with wetlands. It is therefore not possible to mitigate the impact on wetland land capability within areas of the proposed mining footprint.

Significance of unmitigated loss of wetland land capability:

Loss of wetland land capability will have low impact on a spatial scale as it will be localised within the site boundary. The duration of this impact is high for it is permanent. It has high severity for the land capability will be lost completely.

Significance of mitigation measures:

No mitigation measures possible due to the unique functionality of this land capability.

11.3 Summary of impact assessment

Below follows a summary of the impact assessment on soil and land capability of the proposed project site:

Table 6: Summary of soil and land capability impacts

Impact	Unmitigated			Mitigated		
	Severity	Duration	Spatial Scale	Severity	Duration	Spatial Scale
Soil impacts						
Soil erosion	High	High	Low	Medium (+)	Medium	Low
Topsoil degradation	High	High	Low	Medium (+)	Medium	Low
Soil compaction	High	High	Low	Low (+)	High	Low
Soil chemical pollution	High	Low	Medium	High (+)	Low	Low
Land capability impacts						
Loss of arable land capability	High	High	Low	High (+)	High	Low
Loss of grazing/wilderness land capability	Medium	Medium	Low	Medium (+)	Medium	Low
Loss of wetland land capability	High	High	Low	High	High	Low

12. SOIL UTILIZATION GUIDELINES

The Guidelines for the Rehabilitation of Mined Land (as provided by the South African Chamber of Mines) states that soil management during construction is the key process in determining rehabilitation effectiveness and that soil stripping guidelines should be developed for the construction crews which clearly defines the soil horizons to be removed and where and how to store them.

With the similarity in soil characteristics in the three soil forms identified and no presence of B-horizons with significant different characteristics, all topsoil stripped can be stockpiled in the same area. The nature of the project (covering the soil surface with permanent structures) does not require large volumes of topsoil for rehabilitation purposes (such as in the case of opencast mining), however all non-covered surfaces will have to be rehabilitated sufficiently to prevent soil erosion.

Wherever possible, soils should be stripped and immediately replaced in a similar location in the catena (topographical slope) to their natural location. Wetland (hydromorphic) soils should not be stripped and stockpiled at all.

Figures 11 and 12 and Table 14 and 15 summarises the soil forms into broad groups based on the average usable depth of each group and it's stripping and stockpiling potential. The map was used to determine a topsoil volume calculations for rehabilitation purposes.

Table 7: Soil volume calculations for stripping in the TSF area

Soil group	Area (ha)	Depth of topsoil (m)	Volume of topsoil to be stripped and stockpiled (m^3)
Soil with high stripping potential	100.3	1.2	1,203,600
Soils with no stripping potential	6.5	0	0
TOTAL	**106.8**	**-**	**1,203,600**

Table 14 shows that 1,203,600 m³ of soil is present in the proposed TSF area that can be stripped and stockpiled. This does not include wetland soils that is not suitable to be stripped at all. The average depth of 1.2 m was used for the calculations and some areas may be slightly shallower or slightly deeper than 1.2 m.

Table 8: Soil volume calculations for stripping in the infrastructure area

Soil group	**Area (ha)**	**Depth of topsoil (m)**	**Volume of topsoil to be stripped and stockpiled (m^3)**
Soil with medium to low stripping potential	24.8	0.5	1,240,000
Soil with low stripping potential	210.5	0.2	421,000
Soils with no stripping potential	27.4	0	0
TOTAL	**262.7**	**-**	**1,661,000**

Table 15 shows that 1,661,000 m³ of soil is present in the total area around the proposed infrastructure that can be stripped and stockpiled. This does not include wetland soils that is not suitable for stripping at all. Average depths were used for the calculations and some areas may be slightly shallower or slightly deeper.

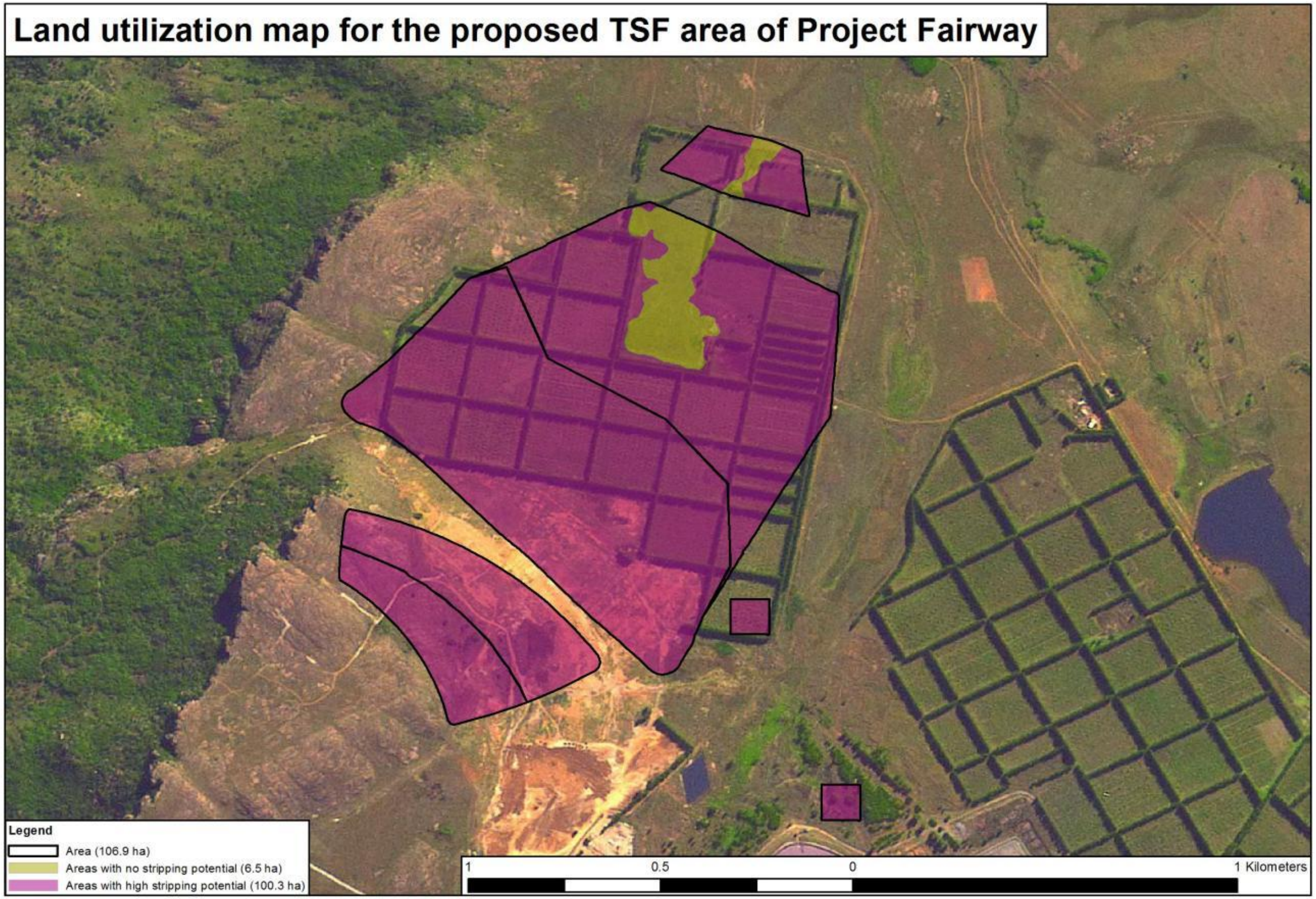

Figure 11: Land utilisation map for the proposed TSF area of Project Fairway

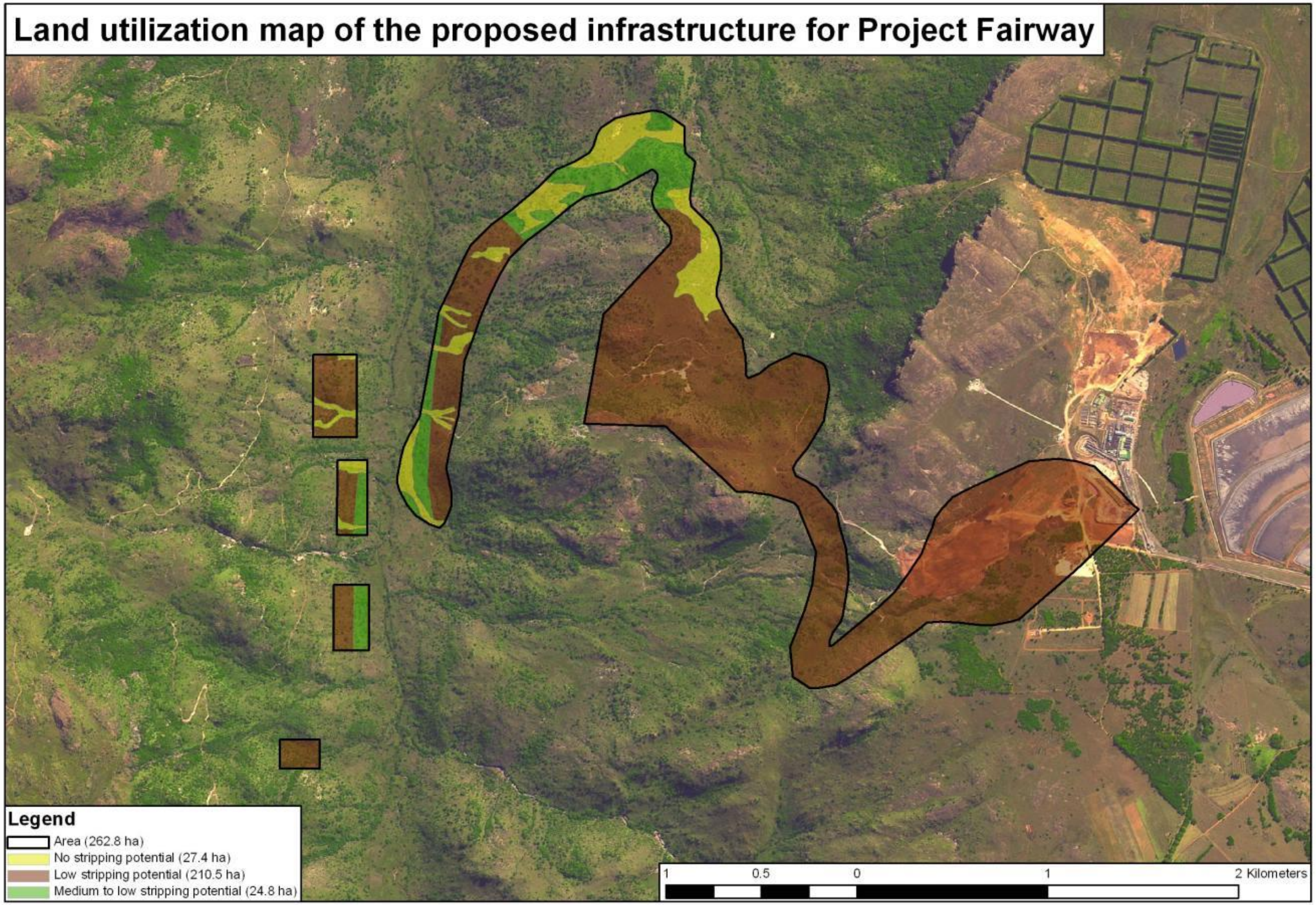

Figure 12: Land utilization map for the proposed infrastructure area of Project Fairway

13. SOIL MANAGEMENT PLAN FOR THE NEW UNDERGROUND MINING AREA

The highest impact that the proposed development will have on the soil in the area is most likely soil erosion in areas where vegetation has been cleared as well as soil compaction. The aim of the soil management plan is to provide guidelines that should be followed during any phase of land preparation, clearing of vegetation or general construction activities.

13.1 Strip a suitable distance ahead of the construction (disturbance) at all times, to avoid loss and contamination

Do not strip too large an area ahead of construction, because this exposes the stripped surface to the risk of water and wind erosion, with the associated dust and water sediment pollution problems. However, if the stripping face is too close to the construction activity, it will result in the loss of valuable soil material. Contamination by overburden materials as well as chemical soil pollution by oil and fuel spills, etc. will occur. This is an easy management measure to implement.

13.2 Supervise stripping to ensure soils are stripped correctly

Close supervision and monitoring of the stripping process is required to ensure that soils are stripped correctly for common failings are stripping too little or too much. When too little, valuable rehabilitation materials are lost, when too much, good quality soil is contaminated with poorer quality and unsuitable materials which are frequently highly compactable and tend to cement when exposed at surface. Risks of soil loss or contamination are particularly high when soil stripping contracts are purely issued on volume stripped, rather than on volume and quality. Monitoring requires assessment of the depth stripped, the degree of mixing of soil materials and the volumes of material replaced directly or placed on stockpiles.

This management measure will only be possible to implement successfully at the TSF where there is clear distinction between the different soil types and the landscape is level enough to be able to do this. Stripping in the valley will be difficult to execute due to the rockiness of the terrain, even under supervision.

13.3 Avoid vegetation clearance and earthworks during the rainy season when chances of runoff and water erosion are highest.

The indigenous vegetation currently protects the highly erodible sandy soil profiles of the study site. The A-horizon is also the most fertile horizon that stabilises plant roots and contains sufficient organic material to allow good water infiltration in the rainy season. This horizon will most likely be stripped during construction and once this layer is removed, the rest of the profile will be extremely susceptible to water erosion. This mitigation measure is highly recommended and although the mine management plan work schedules ahead without avoiding the rainy season, this mitigation measure will be very effective in preventing soil erosion.

13.4 Strip soils only when moisture content will minimise compaction risk

Most soils are highly susceptible to compaction. Compaction is usually greatest when soils are moist, so soils should be stripped when moisture content is as low as possible. Stripping and replacement of soil should be done during the dry season when rainfall is at its lowest and soils are driest. When not practical, every effort must be made to minimise compaction by the methods used for soil stripping, stockpiling and replacement. Although this is a very practical mitigation measure, it will be challenging to implement on site.

13.5 Strip and replace in one action wherever possible

Wherever possible, stripping and replacing of soils should be done in a single action. This is both to reduce compaction and also to increase the viability of the seed bank contained in the stripped surface soil horizons. Stockpiling both increases compaction and decreases the viability of the seed bank, and should only be done when no areas of reshaped impacted land are available for direct placement. This measure will be easy to implement.

13.6 Locate soil stockpiles so that re-handling of soil is minimised

Soil stockpiles should not be moved after initial stripping unless the soil is being replaced in its final location in the rehabilitated profile. This is because each re-handling damages soil structure and increases compaction. Soil losses occur with each re-handling and additional cost is considerable. While it may cost more initially, it is better to place stockpiles in areas where they will not have to be moved. There will always be some soil that has to be stripped before any rehabilitated areas are available for direct placement (for example, soils stripped for roads infrastructure and box-cut development during construction), but these materials should be stockpiled as close as possible to where they are going to be ultimately used. This might not be easy to impement due to the challenges of the terrain.

13.7 Ensure free draining location

Placing soil stockpiles in drainage lines has two major harmful effects: the soils become waterlogged and lose desirable physical and chemical characteristics and the risk of loss of soil materials due to erosion is increased. Ideally, stockpiles should be placed on a topographical crest which provides free drainage in all directions. Alternatively, a side-slope location with suitable cut-off berm construction upslope is acceptable and with a down gradient berm to prevent sedimentation of the surrounding receiving environment. This mitigation measure is easy to implement.

13.8 Minimise compaction during stockpile creation

Soils should be stockpiled loosely. The degree to which soils become compacted during stripping is largely dependent on the equipment used. If shovel and truck are used, the ideal is for soils to be dumped in a single lift. The use of heavy equipment over soil piles results in soil structure damage. If direct dumped soil piles are too low, then it is possible to increase stockpile height using a dozer blade or back-actor bucket to raise the materials.

Running trucks over the piles or using bowl scrapers or graders to level and shape stockpiles, is not recommended. When the only alternative to losing soil material is the use of unsatisfactory (i.e. bowl scraper) equipment, compaction damage can be reduced to some extent by stripping as thick a cut as possible and by dumping it as thickly as possible. In addition, deposition in a single track line may reduce to some extent the overall compaction of the dumped or replaced soil through the minimisation of the footprint area of disturbance. This management measure may be challenging to implement.

13.9 Monitoring and soil audits

A soil monitoring plan should be compiled by the environmental management team of the proposed Project Fairway that will assess the following:

- Quality and volume of topsoil in stockpiles on site
- Areas with soil profiles disturbed outside the proposed footprint area for Project Fairway
- The state of erosion or lack of erosion on site
- Soil compaction levels as measured with a penetrometer in areas with high traffic such as haul roads as well as in stockpiles
- Chemical composition of soil outside TSF areas to determine whether chemical pollutants are leaching from the TSF into the soil;
- Temporal trends in soil contamination over years of monitoring;
- Fate and transport of contaminants;
- Contamination mitigation measures; and
- Measures for program improvement.

This monitoring plan as well as the results of monitoring must be evaluated by an annual soil audit conducted by a soil specialist to make recommendations and comment on existing impacts and issues with regards to soil and land capability conservation.

14. REFERENCES

Chamber of Mines of South Africa. (1981) *Handbook of Guidelines for Environmental Protection,* Volume 3/1981.

The Soil Classification Working Group (1991). *Soil Classification – Taxonomic System for South Africa.* Dept. of Agric., Pretoria.