Project No: WC.KPS.S.12.08.00

ESKOM HOLDINGS SOC (PTY) LTD KENDAL CONTINUOUS ASHING & "E" DUMP EXPANSION PROJECT

SPECIALIST SOILS & LAND CAPABILITY STUDIES BASELINE INVESTIGATION ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT PLAN

Compiled For

ZITHOLELE CONSULTING

May 2014

BASELINE REPORT v1.2

Sustaining the Environment

ESKOM HOLDINGS LTD
KENDEL CONTINUOUS ASHING PROJECT

Compiled for
Zitholele Consulting

Report Number: Baseline report
Client: Zitholele Consulting
Attention: Mr. Gernie Agenbag

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Project Director	Sharon Mayer	Project Leader		
Technical Review				

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ESS Earth Science Solutions

Stonecap Trading 14 (Pty) Ltd

Our Ref: ZC.WD.S.12.04.00
Your Ref: Order No. 12810

22nd May 2014

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Attention: Sharon Mayer

Dear Sharon,

Re: ESKOM HOLDINGS LTD
KENDEL CONTINUOUS ASHING AND "E" DUMP PROJECT
BASELINE SOIL ASSESSMENT, ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT PLAN

Attached please find the baseline assessment of the soils and land capability studies for the area proposed to be used for the continuous ash disposal associated with the Kendal Power Generation Plant (Power Station) as well as the "E" Dump that is proposed for the emergency events that might arise.

The report details the results of the reconnaissance studies undertaken for the specialist soils and land capability sections of the larger EIA being undertaken for the proposed development (expansion of existing Ashing Facility).

Should you have any queries in this regard, please do not hesitate to contact us.

Yours sincerely
Earth Science Solutions (Pty) Ltd

Ian Jones
Director

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Declaration

This specialist report has been compiled in terms of Regulation 33.3 of the National Environmental Management Act 107/1998 (R. 385 of 2006), and forms part of the overall impact assessment for the rehabilitation and closure of infrastructure associated with the Steyldrift Project, both as a standalone document and as supporting information to the overall impact assessment.

The specialist Pedological and Land Capability studies where managed and signed off by Ian Jones (Pr. Sci. Nat 400040/08), an Earth Scientist with 35 years of experience in this field of expertise.

I declare that both, Ian Jones, and Earth Science Solutions (Pty) Ltd, are totally independent in this process, and have no vested interest in the project.

The objectives of the study were to:

- Provide a permanent record of the present soil resources in the area that are potentially going to be affected by the proposed development – Pre development environment,
- Assess the nature of the site in relation to the overall environment and its present and proposed utilization, and determine the capability of the land in terms of agricultural utilization, and
- Provide a base plan from which long-term ecological and environmental decisions can be made, impacts of development can be determined, and mitigation and rehabilitation management plans can be formulated.

The Taxonomic Soil Classification System and Chamber of Developments Land Capability Rating Systems were used as the basis for the soils and land capability investigations respectively. These systems are recognized nationally.

<u>Signed</u>: 23rd May 2014

Ian Jones B.Sc. (Geol) Pr.Sci.Nat 400040/08
Director

GLOSSARY OF TERMS

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

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

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

Calcareous: Containing calcium carbonate (calcrete).

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

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

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

Concretion: A nodule made up of concentric accretions.

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

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

Desert Plain: The undulating topography outside of the major river valleys that is impacted by low rainfall (<25cm) and strong winds.

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

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

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

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

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

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

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

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

Land use: The use to which land is put.

Mottling: A mottled or variegated pattern of colours is common in many soil horizons. It may be the result of various processes *inter alia* hydromorphy, illuviation, biological activity, and rock weathering in freely drained conditions (i.e. saprolite). It is described by noting (i) the colour of the matrix and colour or colours of the principal mottles, and (ii) the pattern of the mottling.

The latter is given in terms of abundance (few, common 2 to 20% of the exposed surface, or many), size (fine, medium 5 to 15mm in diameter along the greatest dimension, or coarse), contrast (faint, distinct or prominent), form (circular, elongated-vesicular, or streaky) and the nature of the boundaries of the mottles (sharp, clear or diffuse); of these, abundance, size and contrast are the most important.

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

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

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

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

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

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

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

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

Texture, soil: The relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page).

The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided (see diagram) according to the relative percentages of the coarse, medium and fine sand subseparates.

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

1. INTRODUCTION AND PHYSIOGRAPHY

1.1 Introduction

The Kendal Continuous Ashing Project (KCAP) covers an area to the northwest and contiguous with the existing Kendal Ash Dump (Refer to Figure 1a and 1b – Proposed Ash Dump Extension and Emergency Ash Dump "E"), an area that is considered a greenfields environment/project, albeit that a significant amount of exploration work has already been undertaken to assess the geotechnical feasibility of the site, while intensive cropping of more than 90% of the area to maize and soya has impacted the soils and the natural land use (low intensity grazing lands).

The effect of commercial farming renders much of the area a "brownfield" site in terms of the impacts that the cultivation and grazing of livestock has had on the soils and land capability, while existing impacts from the deposition of ash from the power generator to the east has had some influence on the cumulative effects on its periphery.

The effects of the existing activities and developments are clearly evident, with both erosion and compaction having impacts on the soil resource and the capability of the land

Eskom Holdings Ltd is in the process of applying for the extension of the Ash Dump to the north and west, as well as the licensing of an emergency ash dumping facility at a position known as the "E" Dump.

The process proposed involves the conveying of the "fly ash" that is produced as a by-product and waste stream from the burning of coal and carbonaceous products in the coal fired power generating plant known as the Kendal Power Station.

The ash is transported by an overland conveyer to the existing licensed facility. This is reaching its life capacity and requires expansion to cater for the on-going waste stream from the power station. The emergency dump "E" is required as a backup to the main ash dump facility in case of problems with the main depositional site and/or its infrastructure (conveyer, stormwater controls and/or the return water collection facility(s).

The support infrastructure for the ash dump will require a dedicated conveyer line, access roads and servicing corridor and a well-engineered and dedicated water seepage and stormwater control facility.

The ash is considered a waste material or discard associated with the burning of coal for the generation of electricity and needs to be managed and catered for as part of the impacts that coal fired power generation has on the environment.

The Ash Dump Extension and associated developments (Return water dams etc.) will definitely result in a number of negative impacts to both the soils and land capability of the area and its immediate surroundings and will potentially have negative effects for the associated ecology and biodiversity that is dependent on the soils and vadose zone.

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

The end land use will inevitably be quite different from that mapped in the baseline study, with the Ash Dump designed as a permanent feature that will be capped and managed as a topographic high in the present landscape. The utilisation and final land use for this feature will need to be determined as part of the final closure plan (as yet unknown/undecided), while the sustainability of the final design and utilisation plan will need to ensure that the structure is stable and free-draining. This will require a well-structured and planned construction phase, with a workable storage and stockpiling plan that will maintain the soils structural and biological conditions, with the aim of achieving a condition of No Net loss if possible.

Disturbance of the baseline environment will potentially result in the sterilisation of the soil resource and possible salinization due to the concentration of salts. The impacts have been assessed, and a number of management and mitigation measures tabled. These measures are imperative if the long term sustainability of this development is to be achieved. The concept of No net Loss will indeed be challenged and the possibility of Offsets being considered for the loss of resource should be considered a reality based on the initial findings.

Of added importance to the earth sciences (physical environment) is an understanding of the socio economics of an area and the possible impacts that the development and its activities (transportation and deposition of a by-product and waste stream) could have on the land owners and land users that make a living or sustain themselves from the soils. This includes the effects that might be felt off site due to the erosion of soil by wind and water and the downstream effects of sedimentary load and soil deposition.

An evaluation at a desktop level of the geomorphology of the area (topography, geology, geohydrology and hydrogeology) indicated that all of the specialist earth sciences would be necessary if a sustainable solution was to be found for the many aspects of change that could affect the area due to a project of this nature.

These (soils and land capability), are but two of the specialist studies that have been earmarked as important to the development of the sustainability plan.

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

These studies are not intended, and must not be used for engineering designs other than the soil stripping and rehabilitation planning. Detailed geotechnical evaluations for materials sourcing and use, are essential for any engineering purposes.

One of the more important outcomes of the soil characterisation and classification exercise was the delineation and characterisation of dominant soils and the rating of the soil sensitivity in terms of the activities being proposed. These aspects are considered meaningful tools and systems that can be used to identify areas that will require added inputs and or consideration in terms of legal requirements and or licensing.

The water law and agricultural authorities require that soil wetness and the agricultural potential of the soils are assessed, with the area in question being considered an important area of food security for the Southern African region in general, and South Africa in particular (local and export markets).

The degree of sensitivity has been catalogued as an important aspect of the baseline investigation, and is used in measuring the relative impact significance.

The baseline has highlighted wet based hydromorphic soils and the shallow ferricrete based materials as areas of high sensitivity and of concern in terms of both management as well as the contribution of these areas to the biodiversity and the ecological importance in the area, while the agricultural potential has been measured as a separate issue in terms of the "land capability" rating, a measure of the arable, grazing or wilderness potential of the land (Chamber of Developments – Land Capability Rating)

The proposed Emergency Ash Dump Facility (E-Dump) and the Continuous Ashing Facility, an expansion to the existing Kendal Ash Dump, will impact on some of the hydromorphic environments identified, with much of the support infrastructure (Return water Dams and Water Control Facilities) having been planned to either traverse the wet based soils and topographic low lying areas that form the streams and water ways in the study areas, or directly within these features. Many of these sites are considered to be highly sensitive areas.

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

The sensitive sites (predominantly stream, water ways and river crossings) will need to be discussed in more detail with the wetland scientist and hydrologist as part of the final design planning. Only with the inputs of the related earth sciences will a full understanding and more in-depth comprehension of these issues be obtained. This information (impact assessment) is invaluable to the development of a workable and sustainable management plan that is based on the spatial extent of the areas of concern. All of these activities and the resultant impacts and effects will ultimately have significance to the biodiversity and ecological status of the area.

This report has been compiled in line with the Guideline Document for Impact Assessment philosophy and Significance Rating System (NEMA).

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

In addition, the impact assessment aims to define a maximum acceptable level of impact for each of the activities, inclusive of any standards, limits and/or thresholds, and assesses the impact in terms of the significance rating as defined by the lead consultants (Refer to Appendix 2). This required that the cumulative effects are considered, and that the common sources of impact are detailed.

1.2 Project Description

The project is considered a Greenfields Project in terms of the Ash Dump that is being proposed (extension to existing facility) and the associated activities that will support the project, but as a Brownfields Project due to the intensive agricultural cultivation and previous impacts of the existing Ash Facilities (Kendal Ash and the existing E Dump structure.

The design plans issued as part of the ToR supplied envisage the expansion of the existing Ash Dump to the west and northwest, the construction of a return water dam and stormwater control facility, and the extension of the existing conveyer system. All of these activities will impact the existing environment to a greater or lesser degree, and will be rated in terms of the soil and land capability/land use sensitivity (Refer to Figure 1a – Ashing Facility, and 1 b and 1c Development Plans for Emergency ("E") Dump respectively).

The size of the venture is considered to be medium to large in terms of the volumes of waste that are planned to be deposited, but moderate to small in terms of the footprint of impact that the activities will have on the surface extent.

The final height of the facilities and the engineering design of the side slopes have been configured to minimise the size of the footprint and optimise the life of the facility. These actions will help to reduce the overall impact.

These facilities (Continuous Ashing and the "E" Dump) will be serviced by a surface stormwater management system (Trenches, Berms and Dams) that will contain all dirty water and separate the clean water. These facilities are part of the footprint of impact and have been considered as part of the overall effect that the proposed development might have on the physical and socio economic environments.

The existing Ashing Facility, Kendal Power Station and the intensive commercial farming activities within the zone of influence of the proposed development will all have an effect on the cumulative impacts. The additional impacts from the proposed Continuous Ashing Development and the Emergency Dump are likely to be confined to the site and possibly the buffer zone if well managed, but could potentially leave the site and be transported by wind or water over large distances if not well managed.

The geology and resultant soils that underlie the development site are typical of the South African coal fields that occur on the eastern Highveld and comprise for the most part sediments of the Vryheid Formation of the Ecca Group (lower Permian age).

The Vryheid Formation consists of alternating sandstones and shale's ranging between coarse and gritty sandstones to shale's with all the intermediate variations between the two extremes.

Eskom Holdings SOC Ltd through their Kendal Project is planning to expand the existing Ash Dump along with the Emergency dump facility to augment the existing operation in order to make provision for the power station waste going forward.

The deposition of the coal fired power station waste as ash is a recognised method of disposing of the waste product on surface.

The premise is that the utilizable soils will be removed and stored as a matter of design and good ethics, while the land use and its inherent capability and resultant sensitivity will be considered prior to any development decisions being made.

Impacts from the erosion of the waste by water or wind are a consideration to be included in the design, while the potential for the salinisation and contamination of the soils both underlying the site as well as to those that are stored, if not well protected must be included in the EIA. Added impacts include hydrocarbons and other reagents that might be needed as part of the Ash Dump operation.

The activities associated with the deposition and storage of ash will disturb the surface features and alter the soils land use and land capability permanently, albeit that the final dump is planned to be shaped and covered with a soil capping that is capable of sustaining a vegetative cover under natural climatic conditions.

With these intentions as part of the rehabilitation and closure plan, it is imperative that a well-designed and sustainable soil utilisation and management plan is developed and implemented as part of the overall life of the development. The specifics of this plan will be spelled out as part of the specialist environmental management plan (EMP) for the soils and land capability.

These actions should be integral and part of the overall design philosophy.

A sustainable end use plan will need to be considered and decided on as part of the design criteria supplied, and will form the basis for the impact assessment (EIA) and EMP.

Using these well established and accepted methods of waste deposition and storage, and assuming that the lining conditions cater for the development of a barrier to infiltration of contaminants to the vadose zone and the soil layer that is left as the ash dump footprint, while the cover design makes allowance for sufficient soil material that has a quality that can sustain a stand-alone vegetative cover and a topography that is free draining.

The permanent nature of the structures being proposed will seriously challenge the concept of No Net Loss, and the overall desire to achieve a truly sustainable project.

An understanding of the pre development conditions is important both in terms of having an accurate record of what exists now and forming the basis for the impact assessment, but also forms the basis for the development of feasible mitigation measures.

Apart from these issues being required in terms of the law, it is important that the potential loss of an important resource (soil and land use) needs to be understood in terms of the sustainability equation and the concept of “No Net Loss”.

In line with the findings, the site specific management planning and mitigation measures for the soils will be defined and detailed once the End Land Use and final design for the dumps is received. The utilisation plan will include the defining of how the mitigation will reduce the intensity and probability of the impact occurring, and what is necessary to ensure that the prescriptive mitigation proposed is clear, site specific and practical, while an estimation of the cost will be attempted based on present costs.

In addition, and as part of the practical management plan, a comprehensive monitoring system will need to be considered.

The Kendal Ashing Facilities are part of the strategic development required in terms of energy production in South Africa, and although this is a new development, it is part of the optimisation and extension to the life of the Kendal Power Station operation.

The lead consultants (Zitholele) contracted Earth Science Solutions (Pty) Ltd (ESS) to assist with the specialist soils and land capability sections of the baseline studies, the assessment of impacts and the development of a soil utilisation and management plan that will aid in the minimisation and mitigation for the life of the development and into the post closure (construction, operation and closure) phase.

The soils and land capability are two of the specialist disciplines that have been considered important aspects of the physical environment, and which will definitely be affected by the activities being proposed.

In the planning of any new development it is important that the impacts are understood prior to the initiation of the design and/or implementation of the project.

The environmental aspects are not least of all part of the information that is needed in this decision making, with an understanding of how the soils and land capability will be affected being just part of the overall sustainability equation that needs to be balanced in terms of the earth life cycle.

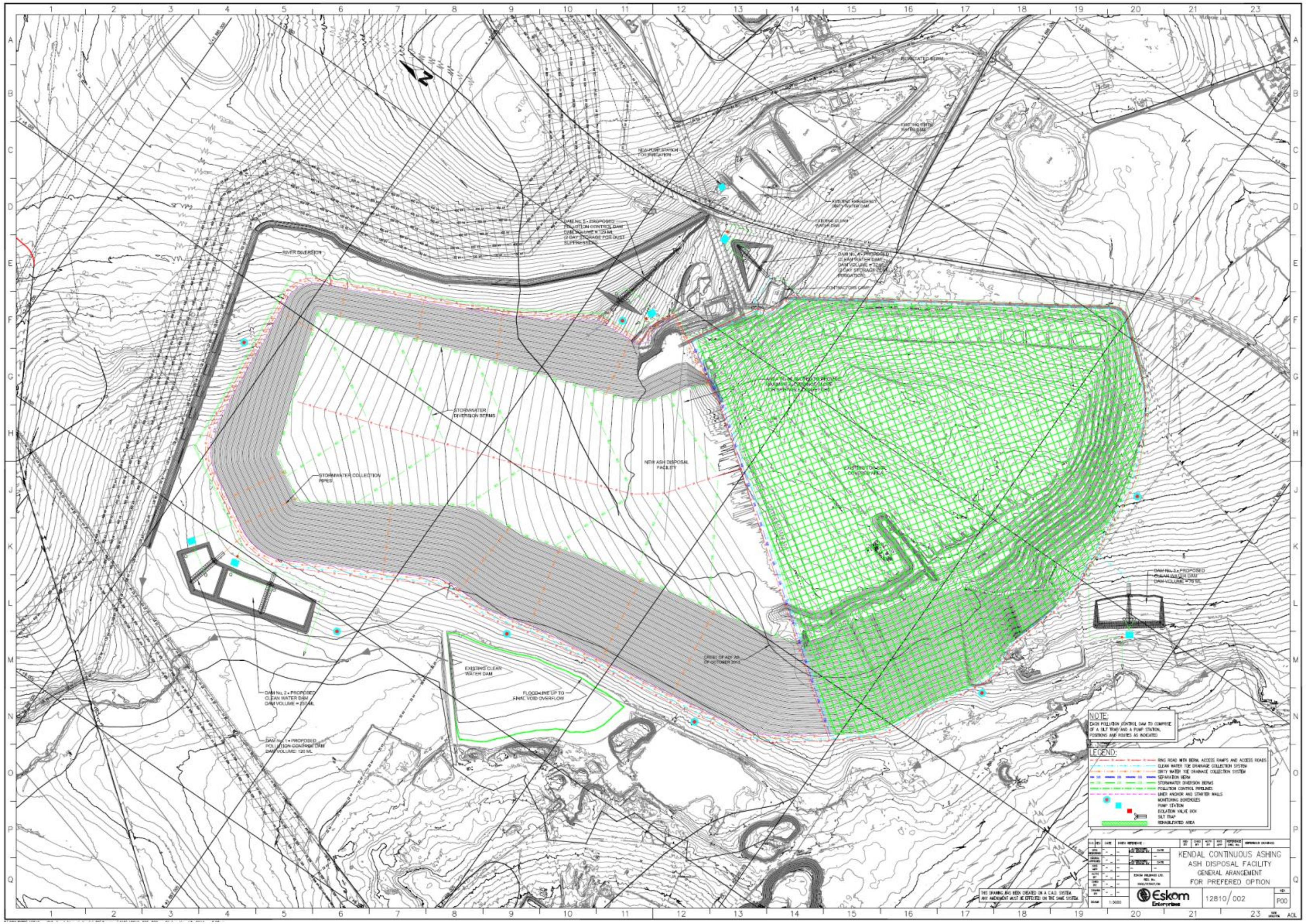

Figure 1a – Proposed Development Plan – Continuous Ashing Site

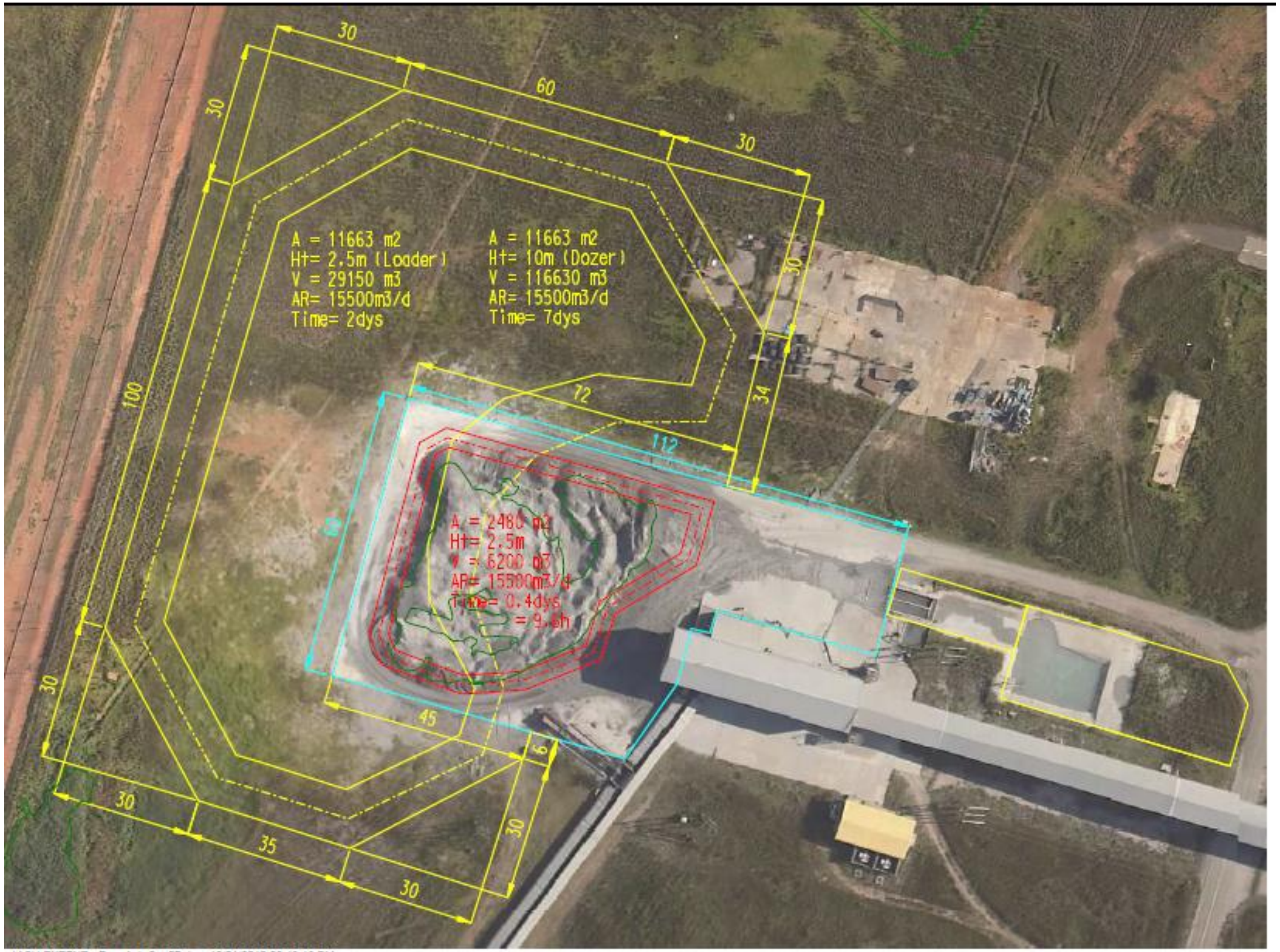

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Figure 1b – Emergency Ash Disposal Site – Proposed “E” Dump

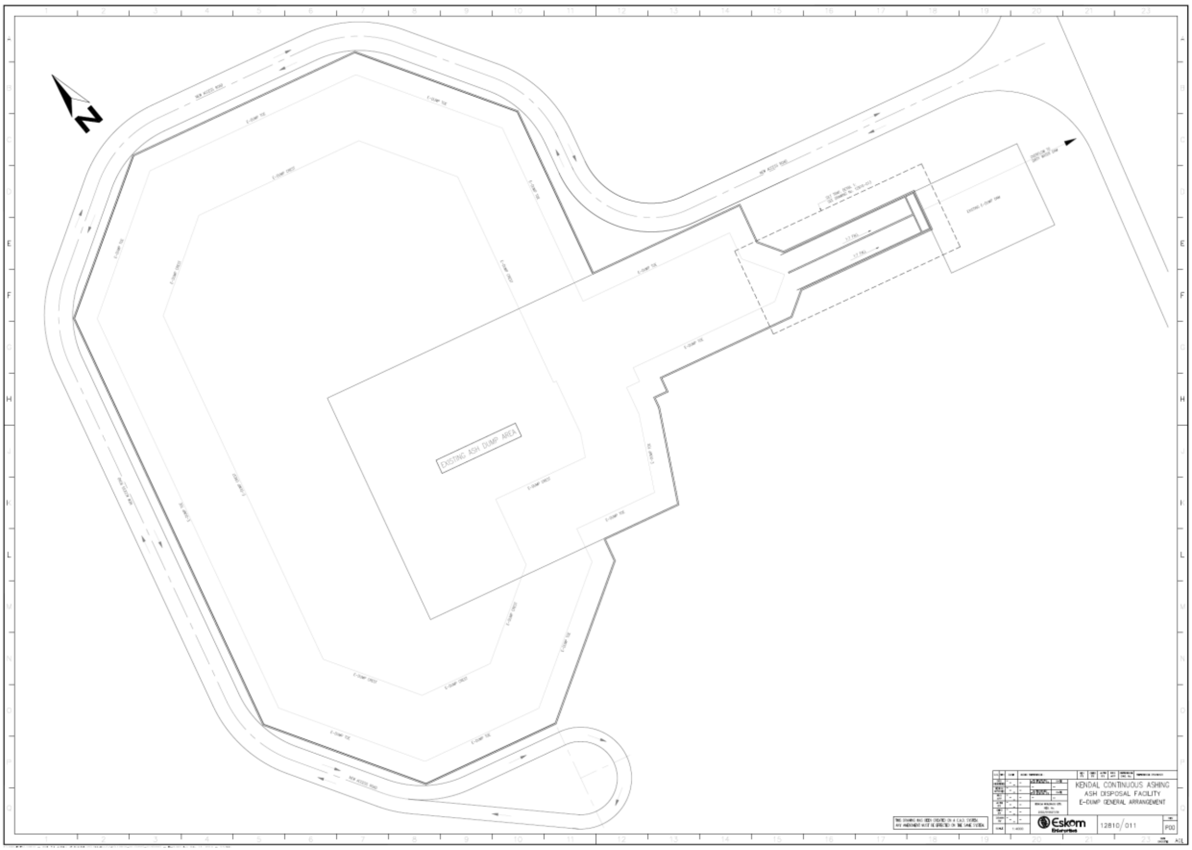

Figure 1c – Emergency Ash Disposal Site – “E” Dump General Configuration

The results of the soils and land capability study have been discussed in terms of their environmental “sensitivity”, with the soils mapping having been simplified based on the dominant soil forms, their functionality and their associated land capability. In this way, the sustainability of the project can be measured in terms of the impacts and related mitigation, with sensitive areas being managed in a sound scientifically derived manner.

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

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

The principle or concept of “No Net Loss” (NNL) has been tabled as the ultimate aim in developing a project that is sustainable. However, the deposition of a waste product such as ash and some of the activities that are being proposed for this project will definitely challenge this concept.

The activities being proposed will definitely have a negative, but variable impact on the natural resources and they are considered to be permanent. The land use will definitely change, and the capability of the soils and the land will alter

1.3 Methodology and Approach

The soil and land capability specialist studies have been tailored to the site specifics, and developed as the basis for the characterisation and classification of the soils and the rating of the land capability.

These soil mapping is based on a specific set of principles as set down in the "Taxonomic Soil Classification, a system designed for South Africa" (described in detail later), but of relevance to many of the Southern African regions as well. These norms are consistent with the NEMA Regulations, World Bank Standards and national nomenclature.

The resultant physical and chemical characteristics of the materials are used to characterise and highlight the site specific sensitivities which are then combined into dominant soils "groupings". The groupings have similar physical and chemical characteristics that will react in a similar manner to the possible impacts predicted, and for which the same mitigation and management measures can be applied under a given set of circumstances.

This simplification of the soil forms can be used by the developer more easily and with better results as part of the planning and decision making tools (Not for design purposes). In addition, the interested and/or affected parties (Public and Authorities) can make more informed and better comment based on well-developed and scientifically based information, all of which will aid in the design of the most sustainable project.

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

The Soil Classification System and Land Capability Rating Systems supply the scientific basis and knowledge needed to determine the sensitivity or vulnerability to the soils of the different actions and activities being proposed.

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

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

Using this philosophy the study area was investigated on a comprehensive reconnaissance grid base and an assessment and understanding of the baseline conditions for the soils and land capability obtained.

The level of study and intensity (spatial variance) of the observations made was guided by a number of practical variables. These included the geomorphology of the site (topography, ground roughness, attitude and climate) and knowledge of the proposed development (development plan) and the actions that are intended.

No detailed soils information was available from any of the regional assessments, and although the Land Type Maps (Government) and Geological Maps were of help in understanding the proposed planning for the area and the high level understanding of the agricultural potential, land capability and associated earth sciences variables, the sensitivities and site specific variations and aspects that are important to the ecological balance of the area were lacking.

1.4 Legal Considerations

As part of understanding the consequences of the proposed development an knowledge of the national legislation that pertains to soils is important, and is a guide in understanding the permissible standards and limits that can be considered, albeit that there are no prescribed quantitative limits that can be quoted.

The most recent South African Environmental Legislation that needs to be considered for any new development with reference to management of soil includes:

- The Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal.
- The Bill of Rights (chapter 2) states that environmental rights exist primarily to ensure good health and wellbeing, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.
- The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely the precautionary principle, the “polluter pays” principle and the preventive principle.
- It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source.
- Soils and land capability are protected under the National Environmental Management Act 107 of 1998, the Development Act 28 of 2002 and the Conservation of Agricultural Resources Act 43 of 1983.
- The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimised and remedied.
- The Development Act 28 of 2002 requires an EMPR, in which the soils and land capability be described.
- The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinization of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and water courses are also addressed.

In addition to the South African legal compliance this proposed development has also been assessed in terms of the International Performance Standards as detailed by the International Finance Corporation (IFC).

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

Performance Standard 1 establishes the importance of:

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

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

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

Of importance to this report are:

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

With regard to the application of relevant standards (either host country or other) there are no specific quantitative guidelines relating to soils and land use/capability, either locally or within the World Bank's or IFC's suite of Environmental Health and Safety Guidelines. However, the World Bank's Development and Milling, guideline does state that project sponsors are required to prepare and implement an erosion and sediment control plan.

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

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

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

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

1.5 Assumptions, Limitations and Uncertainties

It has been assumed that the total area of possible disturbance was included in the area of study, that the development plan as tabled has documented and catered for all actions and activities that could potentially have an impact on the soils and land capability, and that the recommendations made and impact ratings tabled will be re-assessed if the development plan changes.

Limitations to the accuracy of the pedological mapping (as recognised within the pedological industry) are accepted at between 50% (reconnaissance mapping) and 80% (detailed mapping), while the degree of certainty for the soils physical and chemical (analytical data) results has been based on **"composite"** samples taken from the dominant soil types mapped in the study area.

The area in question has been mapped on a comprehensive reconnaissance base, the degree and intensity of mapping and geochemical sampling being considered and measured based on the complexity of the soils noted in field during the field mapping, and the interplay of geomorphological aspects (ground roughness, slope, aspect and geology etc.).

2. DESCRIPTION OF THE PRE-CONSTRUCTION ENVIRONMENT

2.1 Data Collection and Gap Analysis

2.1.1 Review of Available Information

The specialist pedological and land capability studies have been undertaken in phases, with the baseline assessment being undertaken between January and March of 2013. The mapping was based on the Development Plan made available through the lead consultants.

The site specific nature of the proposed development, and the spatial distribution of the resource renders the impact as site specific, and no alternatives can/could be considered other than the no-go option.

Site sensitivities and possible “No Go” considerations have been highlighted wherever pertinent, with specific regard being given to areas of wetness, soil erosion and compaction. When considering the effects that development will have on the surface attributes and soils and land capability in particular, these are the most likely aspects that will affect the loss of resource.

The site specific sensitivities have been highlighted and used in the delineation of environmentally sensitive “No Go” or “High Sensitivity” areas. These considerations are recognised as essential in the process of sustainable development and the obtaining of scientific information that is acceptable to answering the IAP’s and authorities concerns.

As new infrastructure is envisaged (extension of conveyer and excavation of stormwater trenches, dams and construction of berms) that will impact the soils and change the land capability it was important that the baseline study was comprehensive enough, and could be utilised by the developer for site selection actions and the development of a feasible plan for the development venture based on the physical components of the environment.

The government survey maps (geological and topocadastral) and the regional descriptions were used in obtaining an understanding of the general lithological setting for the area, while discussions with the farming community helped in understanding the possible pedogenic processes that could be unique to the specific environment. However, the scale of this information is insufficient for the level of data needed for a project of this magnitude.

Field Work

A reconnaissance pedological study of the site was performed using a comprehensive grid base, for the entire footprint area and a 300m buffer zone around the areas that are being planned for the Continuous Ashing as well as the Emergency Ash Dump facility.

The Ash Dump footprint and all associated support infrastructure and related activities will be subjected to the removal of all utilisable soil, while the footprint associated with the deeper excavations will require that all of the soil and some of the soft overburden will need to be stockpiled and stored. These actions will result in the alteration/modification of the surface topography and will permanently change the land capability and land use. These changes in the landscape (lowering or possible rising of the land surface – bulking factor) will affect the hydrological flow patterns on surface and will potentially result in areas of “ponding” if they are not well managed.

Ponding of surface water and the un-managed increased in infiltration of surface water into the vadose zone will have significant negative implications for the utilisation potential and land capability. These are high negative impacts that are difficult to mend.

Field Methodology

In addition to the grid point observations, a representative selection of the soil forms mapped were sampled and analysed to determine their chemistry and physical attributes. The soil mapping was undertaken on a 1:10,000 scale (Refer to Figure 2.1.2b – Dominant Soils) orthophotographic base.

The majority of observations used to classify the soils were made using a hand operated bucket auger and Dutch (clay) auger.

Standard mapping procedures and field equipment were used throughout the survey.

The fieldwork comprised a number of site visits during which profiles of the soil were excavated and observations made of the differing soil extremes. Relevant information relating to the climate, geology, wetlands and terrain morphology were also considered at this stage, and used in the classification of the soils of the area, while the variation in the natural vegetation was also used to help in the more accurate placing of the changes in soil form.

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

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

Soil Profile Identification and Description Procedure

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

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

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

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

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

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

i. Demarcate master horizons;
ii. Identify applicable diagnostic horizons by visually noting the physical properties:

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

iii. Determined from i) and ii) the appropriate Soil Form
iv. Establishing provisionally the most likely Soil Family

Table 2.1.1 Explanation - Arrangement of Master Horizons in Soil Profile

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

Sample Analysis

Sampling of representative soils was carried out and submitted for analysis.

Factors that were considered in the laboratory included:

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

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

i) The Spectro Atomic Analyser for the determination of the basic elements
ii) The titration method for the determination of Organic Carbon contents, and
iii) The use of a density meter for the determination of the clay contents.

Analytical results are given for the extractable quantities available from the soil (Refer to Tables 2.1.3.1).

2.1.2 Description

Soil Characterisation

The soils encountered can be broadly categorised into four major groupings, with a number of dominant and sub dominant forms that have been grouped and that characterise the area of concern (Refer to Figure 2.1.2b).

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

The generally flat to slightly undulating topography has resulted in the in-situ formation of many of the soils and a moderately well-developed pedogenisis for the site, albeit that the retention of soil water within the vadose zone (lack of preferred horizontal flow) due to the horizontal bedding of the sediments and fine grained nature of the siltstone and mudstone interlayers has resulted in the creation of an inhibiting layer (calcrete/ferricrete) within some of the soil profile. The resultant perched water within the profile creates areas or relatively much wetter soil features, a factor that is considered important to the ecology and biodiversity of the area.

It is hypothesised that, the ferricrete layer that is found associated with the horizontally bedded sediments is responsible for the restrictive layer that is holding water within the soil profile and resulting in the development of moderately extensive areas of wet based soils.

The occurrence of extensive calcrete and/or ferricrete horizons within the soil profile classify as "relic" land forms for the most part, albeit that a significant area of more recent laterite development was mapped in association with the large alluvial river and stream flood plains and the wetlands that make up many of the soils associated with these geomorphologically sensitive areas.

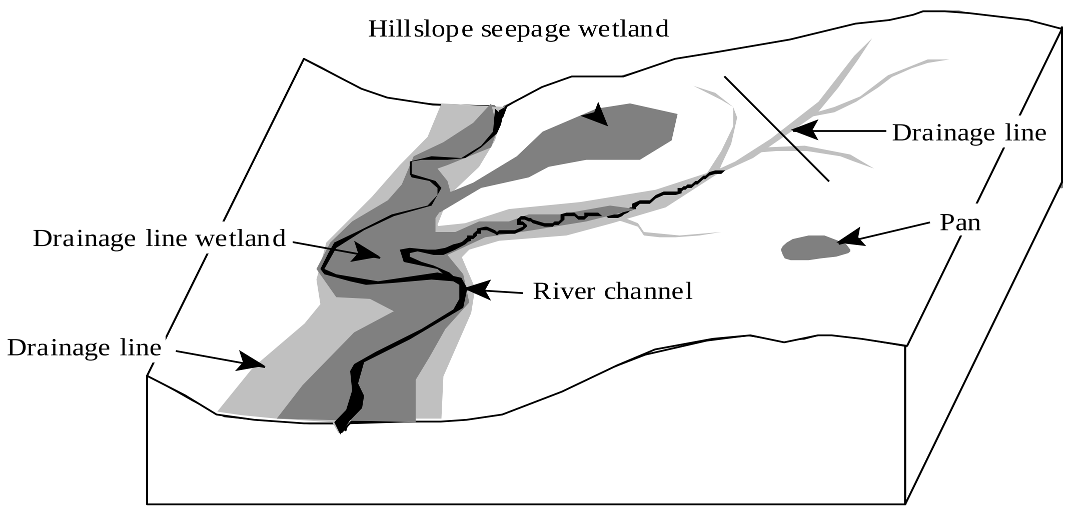

Figure 2.1.2a - Schematic of the Wet Lands and their relation to Topography.

The relic land forms are commonly associated with hillside seeps and "sponge zones" (Refer to Figure 2.1.2b), both of which are associated with possible wetland development.

These ferricrete layers occasionally outcrop at surface as ouklip or hardpan ferricrete and are the basis for many of the pan structures found within the sedimentary profile and landscape of this region. These features are important to the ecological and biodiversity cycle, and are regarded as sensitive to highly sensitive features. In addition, and as part of these sensitive systems, are the "transition zones" that contribute (soils within the pan catchment) to the wetland catchment systems. These areas also need to be considered as part of the sites with a status of high sensitivity.

The dominant soils classified are described in terms of their physical and chemical similarities and to some extent their topographic position and resultant pedogenisis, with their spatial distribution being of importance to the management recommendations (Refer to Figure 2.1.2b – Dominant Soils). The major soil groupings are described in more detail later in this section.

The soils mapped range from shallow sub-outcrop and outcrop of hard plinthite and parent materials (Sediments and intrusive dolerite) to moderately deep sandy loams and sandy clay loams, all of which are associated with either a rocky outcrop of sedimentary parent rock, or ferricrete/laterite "C" horizon at varying depths. The saprolitic horizons are generally quite thin, with soil occurring on hard bedrock in most instances mapped.

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

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

The degree to which the plinthite layer has been cemented (friability of the ferricrete) will determine the effectiveness of the layer as a barrier to infiltration, while the depth of overlying soil will dictate how easily or difficult it is for the soil water to be accessed by the fauna and flora, and in the extreme case weather water is held at surface as a pan.

The friability or ease of excavation (dig-ability) of the ferricrete will also have an effect on the amount of clay mineralisation that the soil contains within this horizon, and will in turn influence the water holding characteristics of the soil and the degree of structure.

In addition to the soil system of classification, a specific system has been developed for the describing and classification of ferricrete (Refer to Appendix 2). This has been used in better understanding the land forms and the overall geomorphology that result from their presence.

In contrast, the deeper and more sandy profiles, although associated with a similar lithological system have distinctly differing pedogenetic processes that are associated with lower clay contents, better drainage of the soils and a deeper weathering profile.

As with any natural system, the transition from one system to another is often complex with multiple facets and variations over relatively small/short distances.

However, in simplifying the trends mapped, the following major soil "groupings" are of importance to this site (Refer to Table 2.1.2):

- The deeper and sandier soils are considered ***High Potential*** materials and are distinguished by the better than average depth of relatively free draining soil to a greater depth (> 700mm). This group are recognisable by the subtleness of the mottling (water within the profile for less than 30% of the season), are noted at greater depths within the profile (>500mm) and the land capability is rated as moderate intensity grazing and/or arable depending on their production potential.

  These soils are generally lower in clay than the associated wet based soils and more structured colluvial derived materials, have a distinctly weaker structure and are deeper and better drained (better permeability). The ability for water to permeate through these profiles is significantly much better than for the structured and wet based soils. In addition, the more sandy texture of this soil group renders them more easily worked and they are rated as having a lower sensitivity (Deep >500mm).

- In contrast, the shallower and more structured materials are considered to be more ***sensitive*** and will require greater management if disturbed. The group of ***shallower and more sensitive soils*** (< 500mm) are associated almost exclusively with the sub outcropping of the parent materials (Karoo Sediments) (geology) at surface, and although they constitute a relatively small percentage of the overall area of study, they have a relatively large and important function in the sustainability of the overall biodiversity of the area.

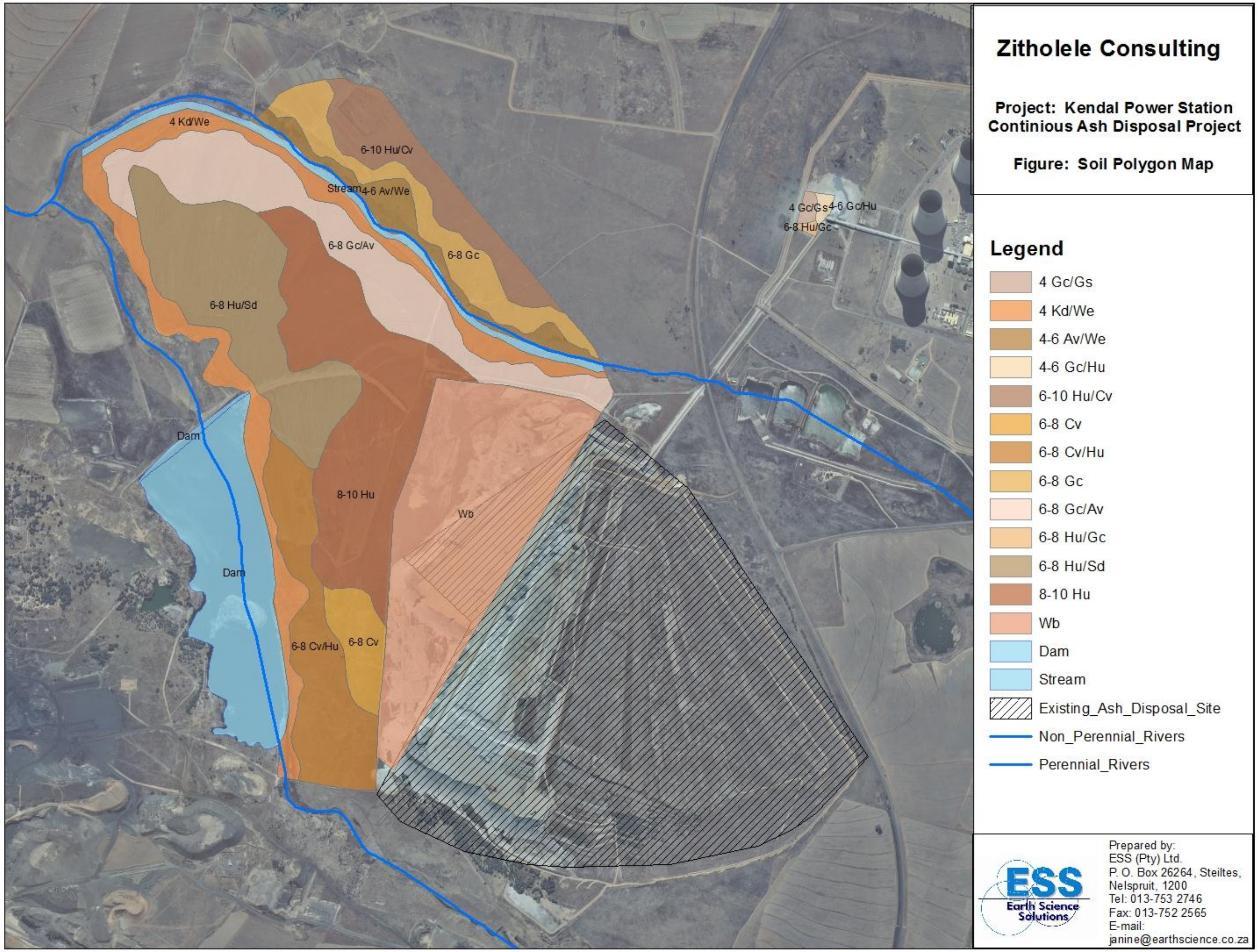

Figure 2.1.2b Dominant Soils Map – Mini Pit and Development Infrastructure

- The third group of soils comprise those that are associated with the hard pan ferricrete layer and perched soil water. This group of soils have a set of distinctive characteristics and nature that are separated out due to their inherently much more difficult management characteristics. These soils are characterised by relatively much higher clay contents (often of a swelling nature), poor intake rates, poor drainage, generally poor liberation of soil water and a restricted depth – often due to the inhibiting barrier within the top 700mm of the soil profile. These soils are generally associated with a ***wet base***.

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

  The groundwater levels are reported to be relatively deep (>12m) for the majority of the area of study and is reported (hydrogeologists) to have little to no influence on the soil water and water found within the vadose zone. No perched aquifers (groundwater) are reported, albeit that a significant area of well-developed ferricrete was mapped within the vadose zone. The development of wet based soils and moist grassland environments are mapped in association with these soil forms.

  Again, it is noted as important to the baseline study, that these soil groupings are moderately extensive in spatial area, and cover a moderately large and sensitive area in terms of the proposed development plan.

  In addition, but not separated from the wet based structured soils are the group of soils that reflect ***wetness*** within the top 500mm. These soils are easily recognised by the mottled red and yellow colours on low chroma background. These soils are regarded as ***highly sensitive*** zones that will require authorisation/permission if they are to be impacted. The legal implications (licensing) will need to be considered if these soils are to be impacted.

  The concentrations of natural salts and stores of nutrients within these soils are again a sensitive balance due to the extremes of rainfall, wind and temperature. The ability of a soil to retain moisture and nutrients, and in turn influence the sustainability of vegetative growth and affect the dependence of animal life is determined by the consistency and degree of soil moisture retention within the profile, and out of the influence of evaporation.

  These conditions and associated sensitivities should be noted in terms of the overall bio-diversity balance if the sustainability equation is to be managed and mitigation engineered. The shallow wet based soils are an important contributor to the ecological cycle.

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

2.1.3 Soil Chemical and Physical Characteristics

A suite of representative samples from the differing soil forms were taken and sent for analyses for both chemical and physical parameters Refer to Table 2.1.3. A select number of samples were submitted, each sample containing a number of sub samples from a particular soil Form which is representative of the area in question. These "composite samples", are representative of the general Soil Form mapped in the area rather than a specific point sampled.

2.1.3.1 Soil Chemical Characteristics

Sampling of the soils for nutrient status was confined where possible to areas of undisturbed land. However, most of the better soil exposure is associated with land that has, or could have been disturbed by farming activities. The results are representative indications of the pre-construction conditions and are representative of the baseline conditions.

It is important to remember that the soils will change while in storage, and the results tabled here will need to be verified for particular sites as and when rehabilitation is started.

On-going sampling and monitoring of the in-situ conditions will be necessary throughout the operational phase to accurately define the post operational conditions if the rehabilitation is to be successful.

The results of the laboratory analysis returned a variety of materials that range from very well sorted sandy loams with lower than average nutrient stores and moderate clay percentages (<20% - B2/1) to soils with a moderately stratified to weak blocky structure, sandy loam to clay loam texture and varying degrees of utilizable nutrients on the colluvial derived materials, and the extremes of much higher clay and stronger structure that are generally associated with the wet based and wetland soils associated with the alluvial derived and bottom land floodplain wetlands.

In general, the pH ranges from acid at 5.8 to neutral and slightly alkaline at 7.5, a base status ranging from 5.2me% to 22.8me% [Mesotrophic (moderate leaching status) to Dystrophic (Highly leached)], and nutrient levels reflecting generally acceptable levels of calcium and magnesium, but deficiencies in the levels of potassium, phosphorous, and zinc, with low stores of organic carbon matter.

The more structured (moderate blocky) and associated sandy and silty clay loams returned values that are indicative of the more iron rich materials and more basic lithologies that have contributed to the soils mapped. They are inherently low in potassium reserves, and returned lower levels of zinc and phosphorous.

The growth potential on soils with these nutrient characteristics is at best moderate to poor and additions of nutrient and compost are necessary if commercial returns are to be achieved from these soils. They are at best moderate to good grazing lands.

Soil fertility

The soils mapped returned at best moderate levels of some of the essential nutrients required for plant growth with sufficient stores of calcium and magnesium. However, levels of Na, Zn, P, and K are generally lower than the optimum required. These conditions are important in better understanding the land capability ratings that are recorded, with the majority of the study area being rated as low intensity grazing land.

These poor conditions for growth were further compounded by the low organic carbon (< 0.75%).

There are no indications of any toxic elements that are likely to limit natural plant growth in the soils mapped within the study area

Table 2.1.3.1 Analytical Results

Sample No.	CA1	CA2	CA3	CA4	CA5	CA6	CA8	EEP15	EEP19	ED1	ED2	Optimum Range
Soil Form	Cv	Av	Gc	Pn	Ka	Hu	Kd	Sd/Hu	Rg	Dr	We	
Constituents mg/kg												
pH	6.25	6	5.5	6.5	5.2	6.4	6.4	6	5.5	6.1	6.4	5.2 - 6.5
"S" Value	11.2	8.9	22.1	14.8	31	11	22	22.8	33	5.2	5.8	
Ca Ratio	59	70	66	65	62	65	49	68	62	70	65	55-75
Mg Ratio	16	24	30	32	34	22	28	34	34	28	10	18-30
K Ratio	18	4	1	1	7	4	8	4	9	0.6	12	6-10
Na Ratio	0.2	0.3	0.2	1.6	1.1	0.5	0.3	0.4	0.8	1.4	0.2	
P	111	22	8	6	17	10	15	12	20	5	82	20 -80
Zn	7.2	2	1	1.1	1.4	1.5	1.4	2	1.1	1	1.6	2-10
Sand	45	42	34	46	18	52	21	42	16	58	44	
Silt	39	36	38	46	22	30	27	26	26	34	35	
Clay	16	22	28	8	60	18	52	32	58	8	21	15 -25
Organic Carbon %	0.15	0.32	0.45	0.12	0.75	0.45	0.6	0.8	0.2	0.15	0.2	>0.75

Nutrient Storage and Cation Exchange Capacity (CEC)

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

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

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

Generally, the CEC values for the soils mapped in the area are moderate.

Soil organic matter

The soils mapped are generally low in organic carbon. This factor coupled with the moderate to high clay contents for the majority of the soils mapped will adversely affect the erosion indices for the soils.

2.1.3.2 Soil Physical Characteristics

The majority of the soils mapped exhibit apedal to weak crumby structure, low to moderate clay content and a dystrophic leaching status. The texture comprises sandy to silty sands for the most part, with much finer silty loams and clay loams associated with the colluvial and alluvial derived materials associated with the lower slope and bottom land stream and river environs respectively.

Of significance to this study, and a feature that is moderately common across the site where the soils are associated with the sedimentary host rocks (albeit that it often occurs below the 1.5m auger depth on the deeper soils) is the presence of a hard pan ferricrete (plinthite) layer within the soil profile.

The semi-arid climate (negative water balance) combined with the geochemistry of the host rock geology are conducive to the formation of evaporites, with the development of ferruginous layers or zones within the vadose zone. The accumulation of concentrations of iron and manganese rich fluids in solution will result in the precipitation of the salts and metals due to high evaporation (negative water balance). This process results in the development of a restrictive or inhibiting layer/zone within the profile over time.

The negative water balance is evidenced by the generally low rainfall of 800mm/year or less, and the high evaporation that averages 1,350mm/year. These are the driving mechanisms behind the ouklip or hard pan ferricrete mapped.

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

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

The soil classification system takes cognisance of ferricrete and has specific nomenclature for these occurrences (Refer to The South African Taxonomic Soil Classification – See list of references).

The variation in the consistency of the evaporite layer, its thickness and extent of influence across/under the site are all important to the concept of a restrictive horizon or barrier layer that is formed at the base of the soil profile and/or close to the soil surface. Where this horizon develops to a nodular form or harder (Nodular, Honeycomb and Hard Pan) the movement of water within the soil profile is restrict from vertical movement and is forced to move laterally or perch within the profile. It is this accumulation of soil water and the precipitation of the metals from the metal and salt rich water that adds progressively to the ferricrete layer over time.

Important to an understanding of the development of the ferricrete is the geological time and presence of the specific soil and water chemistry under which the horizon forms. This situation will be very difficult to emulate or recreate if impacted or destroyed.

2.1.4 Soil Erosion and Compaction

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

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

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

The majority of the soils mapped can be classified as having a moderate to high erodible erodibility index in terms of their organic carbon content and clay content, albeit that this rating is off-set and tempered by the undulating to flat terrain to an index of moderate or resistant.

However, the vulnerability of the "B" horizon to erosion once the topsoil and/or vegetation is removed must not be under estimated when working with or on these soils. These horizons (B2/1) are vulnerable and rate as medium to high when exposed.

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

Loss of soil (topsoil and subsoil) is extremely costly to any operation, and is generally only evident at closure or when rehabilitation operations are compromised.

Well planned management actions during the planning, construction and operational phases will save time and money in the long run, and will have an impact on the ability to successfully "close" an operation once completed.

2.2 Pre-Construction Land Capability

2.2.1 Data Collection

Based on a well-developed and scientifically founded baseline of information, the South African Chamber of Developments (1991) Land Capability Rating System in conjunction with the Canadian Land Inventory System has been used as the basis for the land capability study.

Using these systems, the land capability of the study area was classified into four distinctly different and recognisable classes, namely, wet land or lands with wet based soils, arable land, grazing land and wilderness or conservation land. The criteria for this classification are set out in Table 2.2.1.

Table 2.2.1 Criteria for Pre-Construction Land Capability (S.A. Chamber of Developments 1991)

<u>Criteria for Wetland</u>

Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water dependent.

<u>Criteria for Arable Land</u>

Land, which does not qualify as having wetland soils.
The soil is readily permeable 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 less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm.
Has a slope (in %) and erodibility factor ("K") such that their product is <2.0
Occurs under a climate of crop yields that are at least equal to the current national average for these crops.

<u>Criteria for Grazing Land</u>

Land, which does not qualify as having wetland soils or arable land.
Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm.
Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.

<u>Criteria for Conservation of Land</u>

Land, which does not qualify as having wetland soils, arable land or grazing land, and as a result is regarded as requiring conservation practise/actions.

2.2.2 Description

The “land capability classification” as described above was used to characterise and classify the soil polygons or units of land identified during the pedological survey.

These combined with the geomorphological aspects (ground roughness, topography, climate etc.) of the site were then employed to rate the capability of the land in question.

The area to be disturbed by the proposed ash deposition and its surface infrastructure development comprises a range of land capability classes, with significant areas of friable and good grazing potential class soil, smaller areas or good arable potential materials and significant areas associated with the lower lying areas topographically of highly sensitive sites that returned wet based soils. The colluvial derived soils are at best considered to have a low intensity grazing land potential or wilderness status.

Figure 2.2.2a and 2.2.2b illustrates the distribution of land capability classes across the study area.

Arable Land

The arable potential for the majority of the soils mapped is low unless substantial quantities of fertiliser and manure are added. Some soil depths are reflective of a arable status (>750mm), however, the growth potential (nutrient status and soil water capabilities) and ability of these soils to return a cropping yield equal to or better than the national average is lacking. This is due mainly to the poor rainfall and less than optimum nutrient status of many of the soils. These variables reflect the natural conditions, and do not include any man induced additives such as fertilizers or water.

Grazing Land

The classification of grazing land is generally confined to the shallower and transitional zones that are well drained. These soils are generally darker in colour, and are not always free draining to a depth of 750mm but are capable of sustaining palatable plant species on a sustainable basis (only the subsoil’s at a depth of >500mm are periodically wetted). In addition, there should be no rocks or pedocrete fragments in the upper horizons of this soil group. If present it will limit the land capability to wilderness land.

The majority of the study area classifies as low intensity grazing land or wilderness status.

Wilderness / Conservation Land

The shallow rocky areas and soils with a structure stronger than strong blocky (vertic etc.) are characteristically poorly rooted and support at best very low intensity grazing, or more realistically are of a Wilderness character and rating.

Wetland (Areas with wetland status soils)

Wetland areas in this document (soils and land capability) are defined in terms of the wetland delineation guidelines, which use both soil characteristics, the topography as well as floral and faunal criteria to define the domain limits (Separate Wetland Delineation has been undertaken). Only the soils are described here.

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

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

A significant but relatively small proportion of the study area classifies as having wet based soils. However it is important to note that a significantly large area of the open pit and infrastructure development being planned encroaches on soils with a wet base.

These should not be mistaken as wetlands in terms of the delineation document, but should be highlighted as potential zones of sensitivity with the potential for highly sensitive areas associated with the prominent waterway associated with the development area.

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

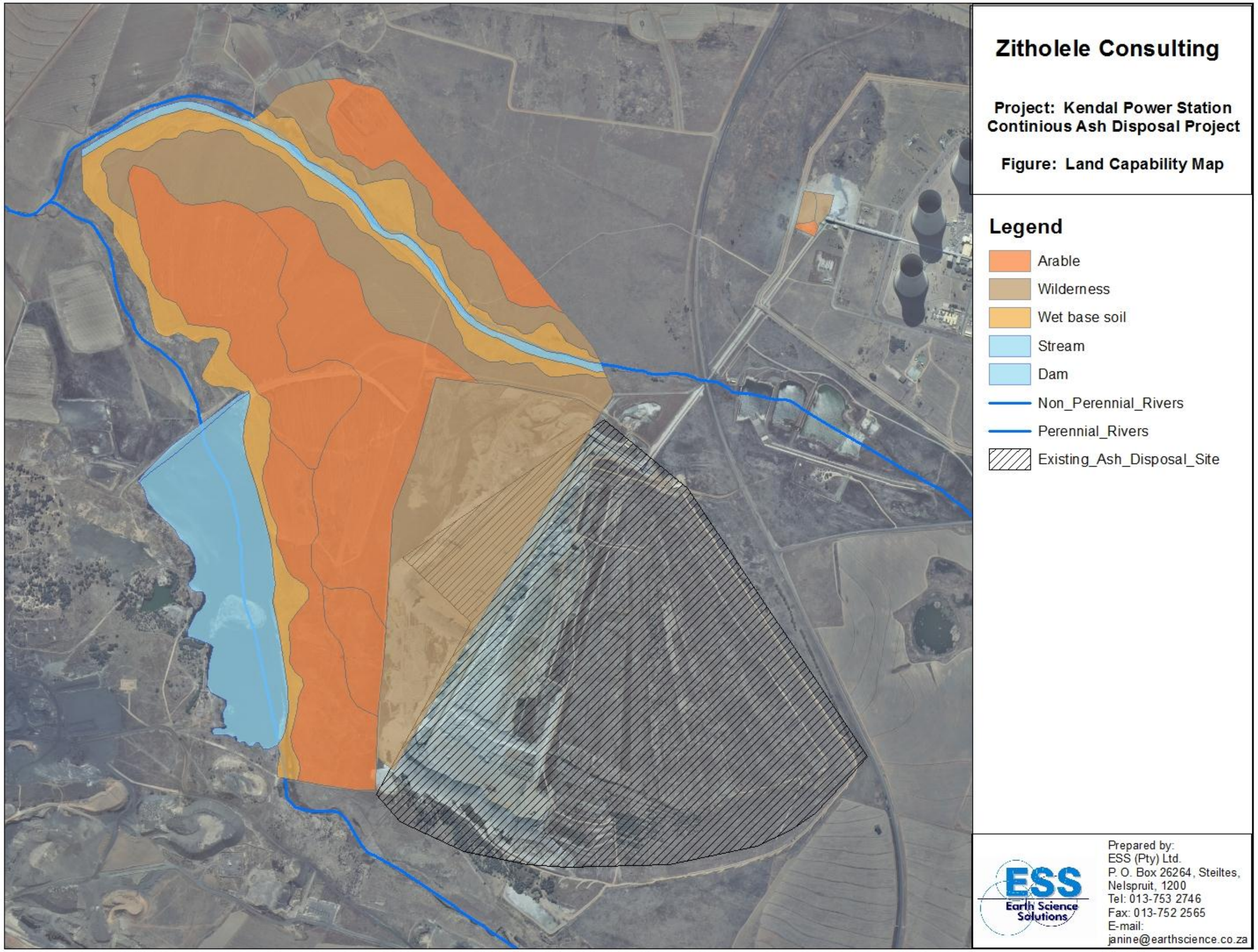

Figure 2.2.2a Land Capability Map – Development Areas

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APPENDIX 1

VETIVER GRASS

APPENDIX 2

FERRICRETE CLASSIFICATION