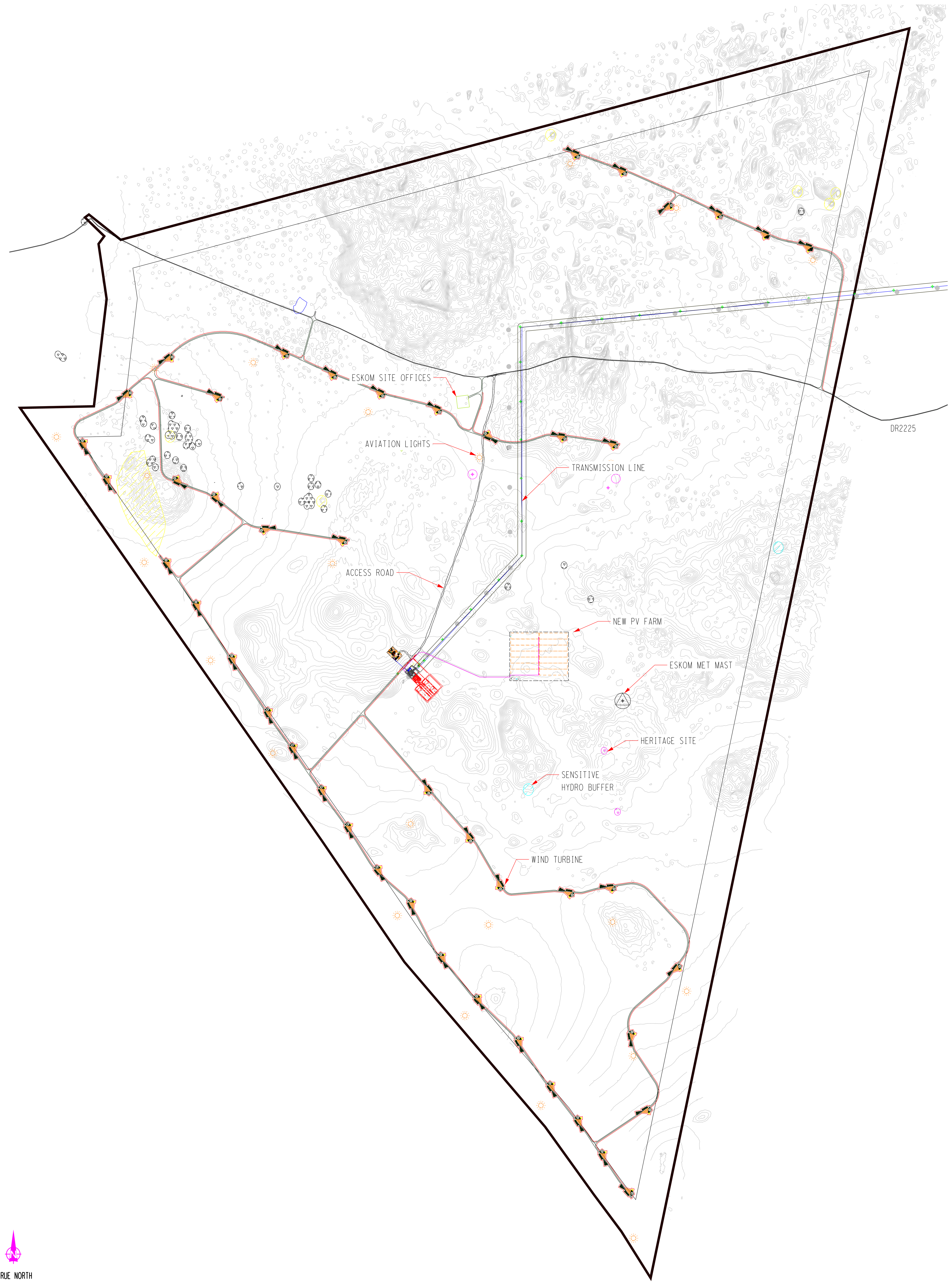
APPENDIX E

TECHNICAL REPORTS AND DRAWINGS



UTM WGS84 SOUTH ZONE 34

COORDINATE	EASTING (X)	NORTHING (Y)
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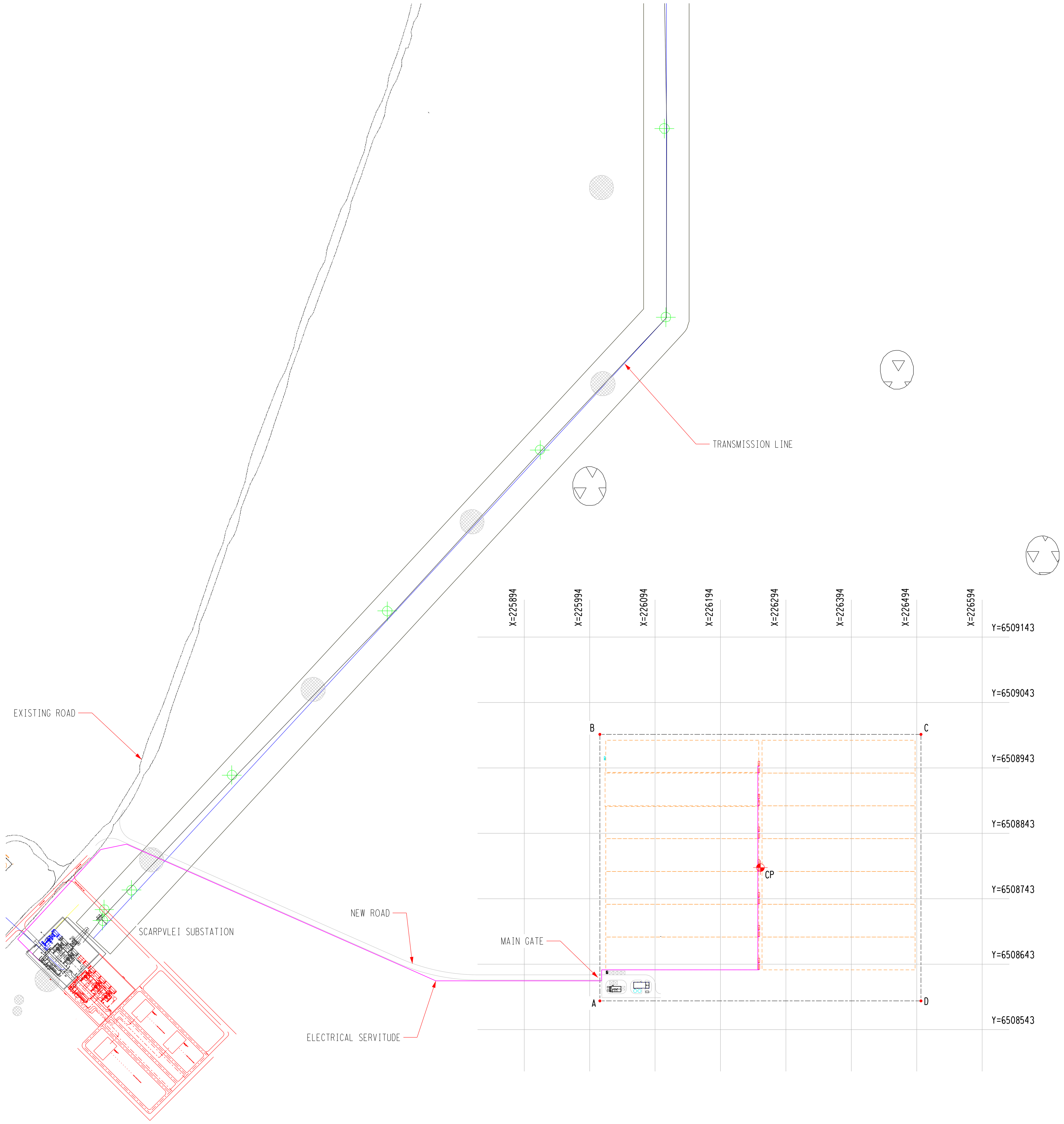
D	226500.4187	6508586.9000
CP	226254.9962	6508790.6000

LOCATION PLAN



SITE PLAN

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

AUTHORISED FOR ESKOM BY:

CODIFICATION BY:

APPROVED BY:

CHECKED BY:

CREATED BY: W MOSES 2021-09-03

SCALE

CLASSIFICATION

PBS PATH

ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

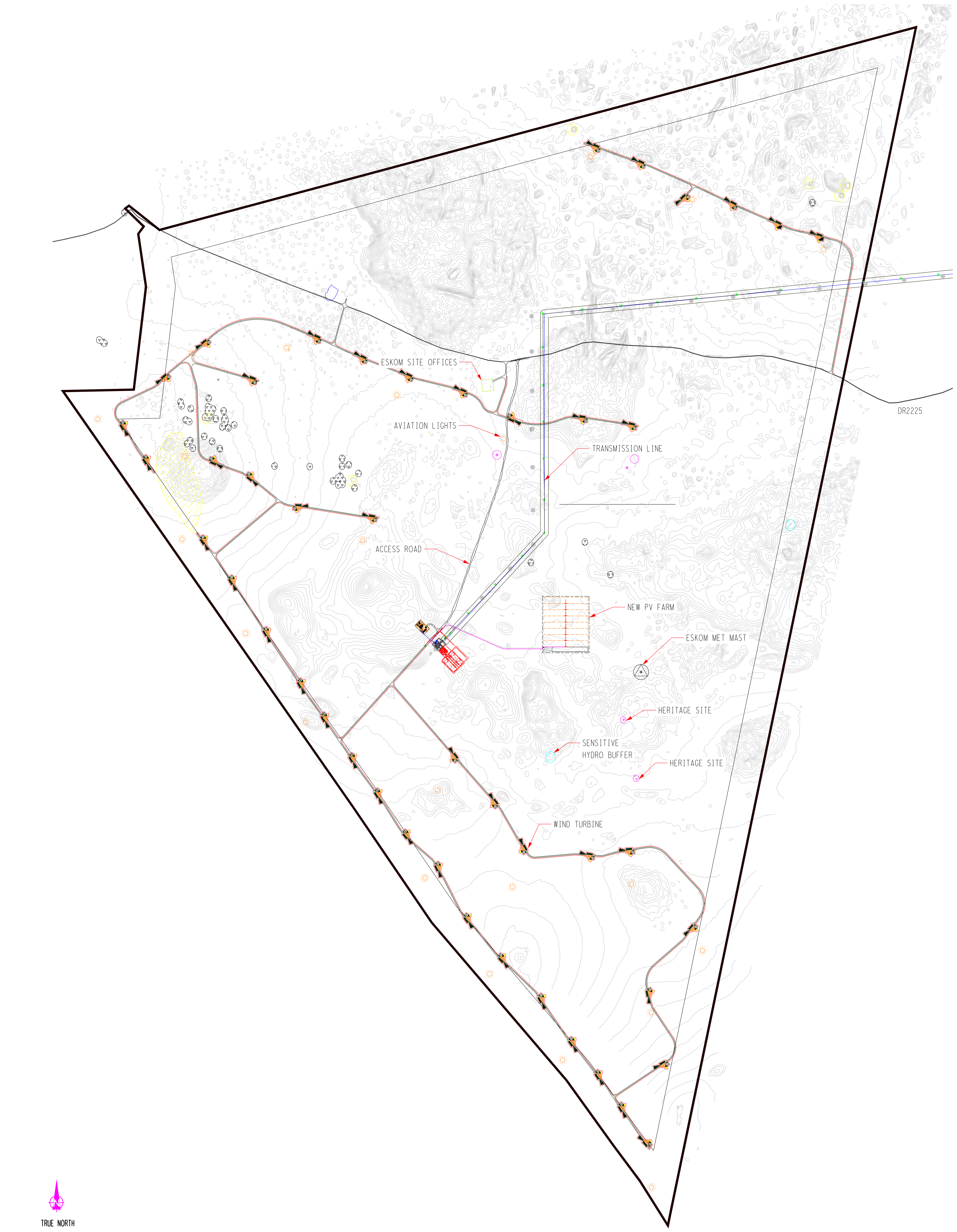
SERE POWER STATION

SITE LAYOUT
UNIT 0
PROPOSED ALTERNATIVE B
SOLAR FARM

ESKOM DRAWING NO | SHT | REV

SIZE A0L

DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE



UTM WGS84 SOUTH ZONE 34

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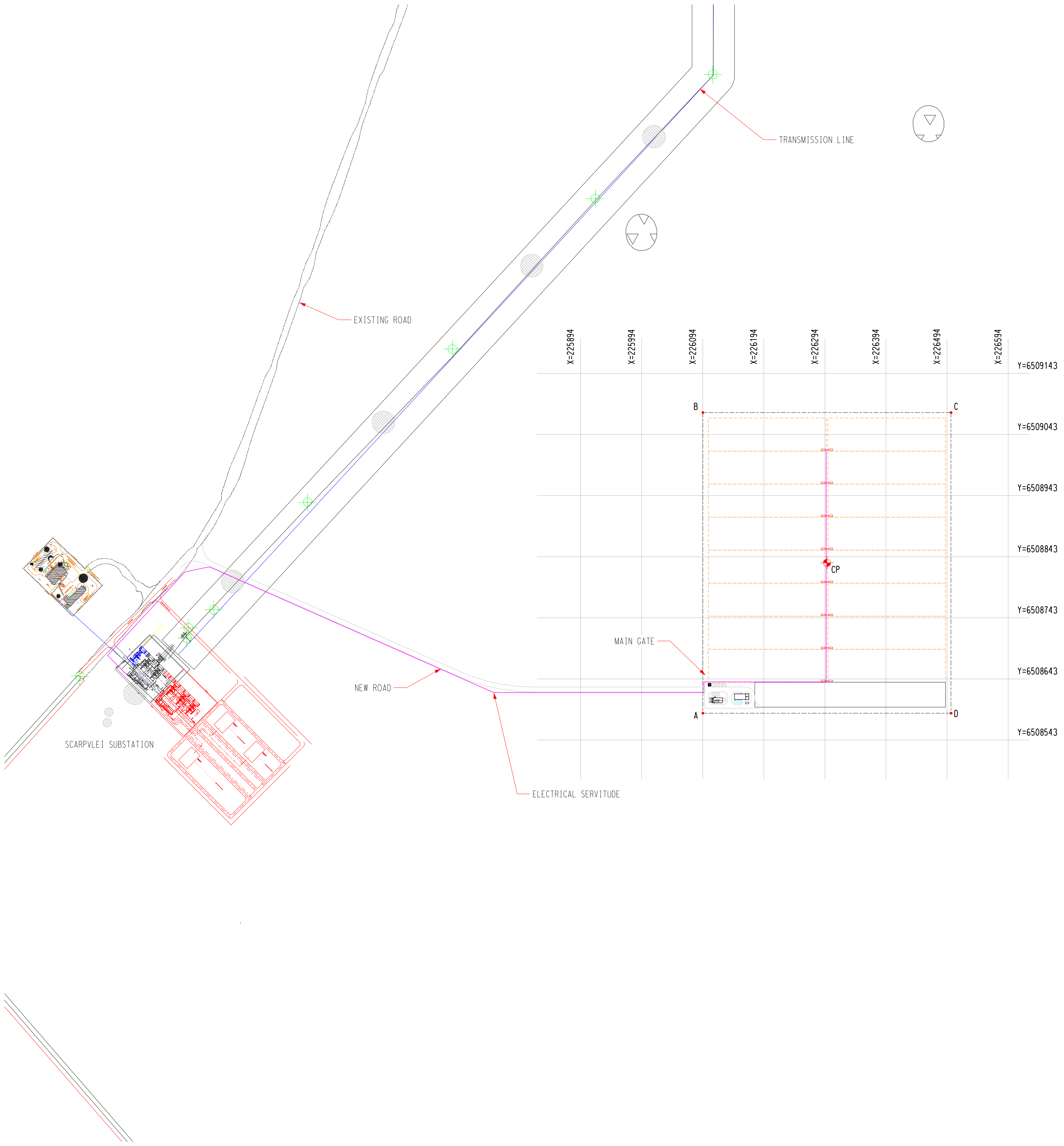
LOCATION PLAN



SITE PLAN

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
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AUTHORISED FOR ESKOM BY:

CODIFICATION BY:

APPROVED BY:

CHECKED BY:

CREATED BY:
W MOSES 2021-06-14

SCALE -----

CLASSIFICATION

PBS PATH

Eskom
ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

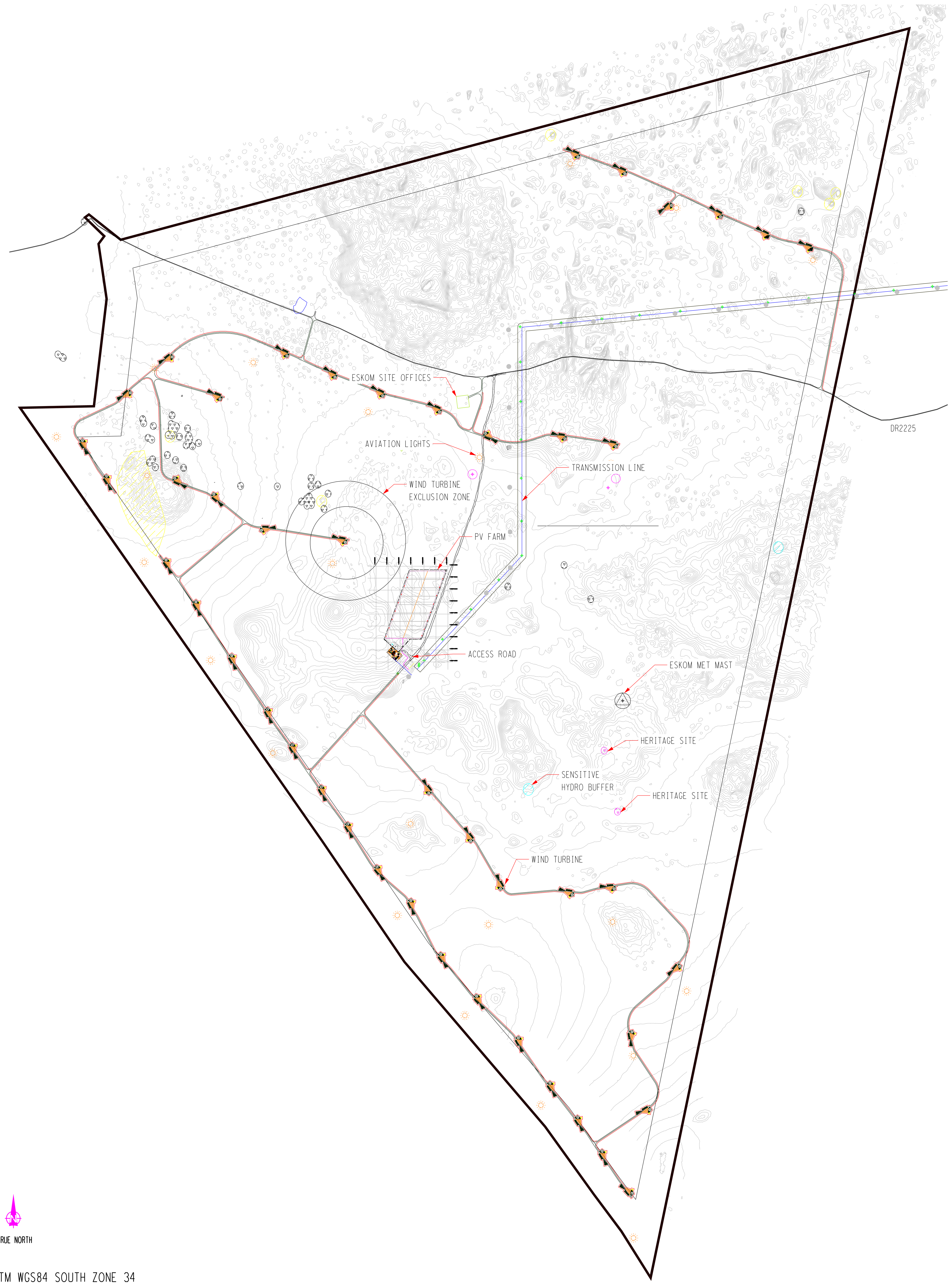
SERE POWER STATION

SITE LAYOUT
UNIT 0
PROPOSED
SOLAR FARM

ESKOM DRAWING NO | SHT -- | REV --

SIZE A0L

DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE



UTM WGS84 SOUTH ZONE 34

COORDINATE	EASTING (X)	NORTHING (Y)
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B	224958.0551	6508932.3519
C	225170.8830	6509514.3712
D	225485.6713	6509514.3712
E	225272.8434	6508932.3519
F	225176.6476	6508932.3519

LOCATION PLAN

SITE PLAN

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

AUTHORISED FOR ESKOM BY:
CODIFICATION BY:
APPROVED BY:
CHECKED BY:
CREATED BY: W MOSES 2021-06-22
SCALE

CLASSIFICATION
PBS PATH

Eskom
ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

SERE POWER STATION

SITE LAYOUT
UNIT 0
PROPOSED FIXED ALTERNATIVE A
SOLAR FARM

ESKOM DRAWING NO 0.95/56 SHT 01 REV 00

SIZE AOL

DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE

94 x 39 (ROW)	PANELS PER ROW (LONG)
76 x 1 (ROW)	PANLES PER ROW (SHORT)
40	ROWS PER BLOCK
16	PV BLOCKS
59 872	PV PANELS
16MW	PV MEGAWATTS

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

AUTHORISED FOR ESKOM BY:

CODIFICATION BY:

APPROVED BY:

CHECKED BY:

CREATED BY: W MOSES 2022-06-22

SCALE

CLASSIFICATION

PBS PATH

ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

SERE POWER STATION

STATION LAYOUT
UNIT 0
PROPOSED FIXED ALTERNATIVE A
SOLAR FARM

ESKOM DRAWING NO 0.95/XX | SHT 01 | REV 00

SIZE A0L

DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE

96	PANELS PER ROW
50	ROWS PER BLOCK
11	PV BLOCKS
52 800	PV PANELS
14MW	PV MEGAWATTS

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

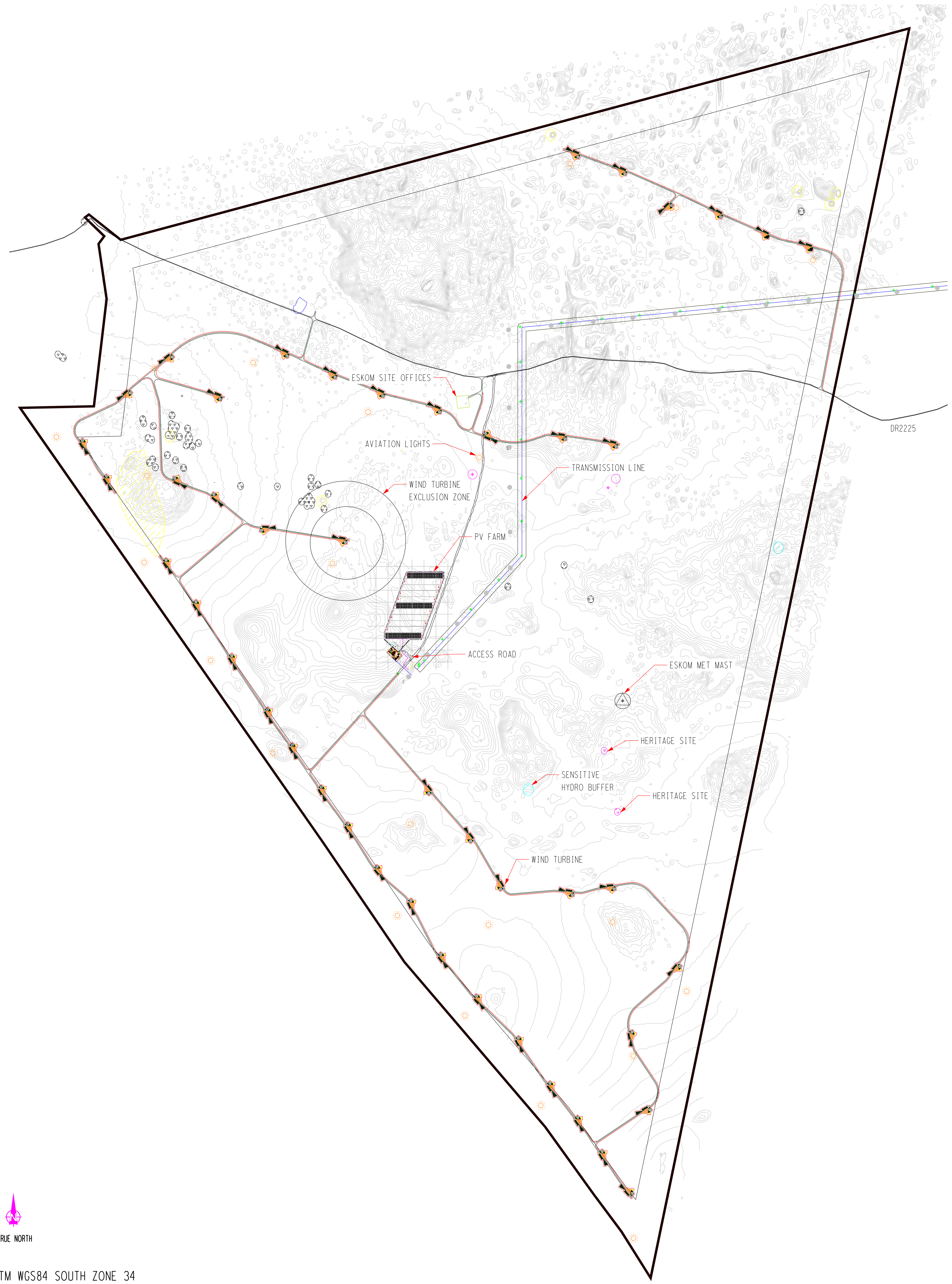
AUTHORISED FOR ESKOM BY:
CODIFICATION BY:
APPROVED BY:
CHECKED BY:
CREATED BY: W MOSES 2022-06-22
SCALE
CLASSIFICATION
PBS PATH

ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

SERE POWER STATION
STATION LAYOUT
UNIT 0
PROPOSED 1 AXIS ALTERNATIVE B
SOLAR FARM

ESKOM DRAWING NO 0.95/XX SHT 01 REV 00

SIZE AOL
DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE



LOCATION PLAN

TRUE NORTH

UTM WGS84 SOUTH ZONE 34

COORDINATE	EASTING (X)	NORTHING (Y)
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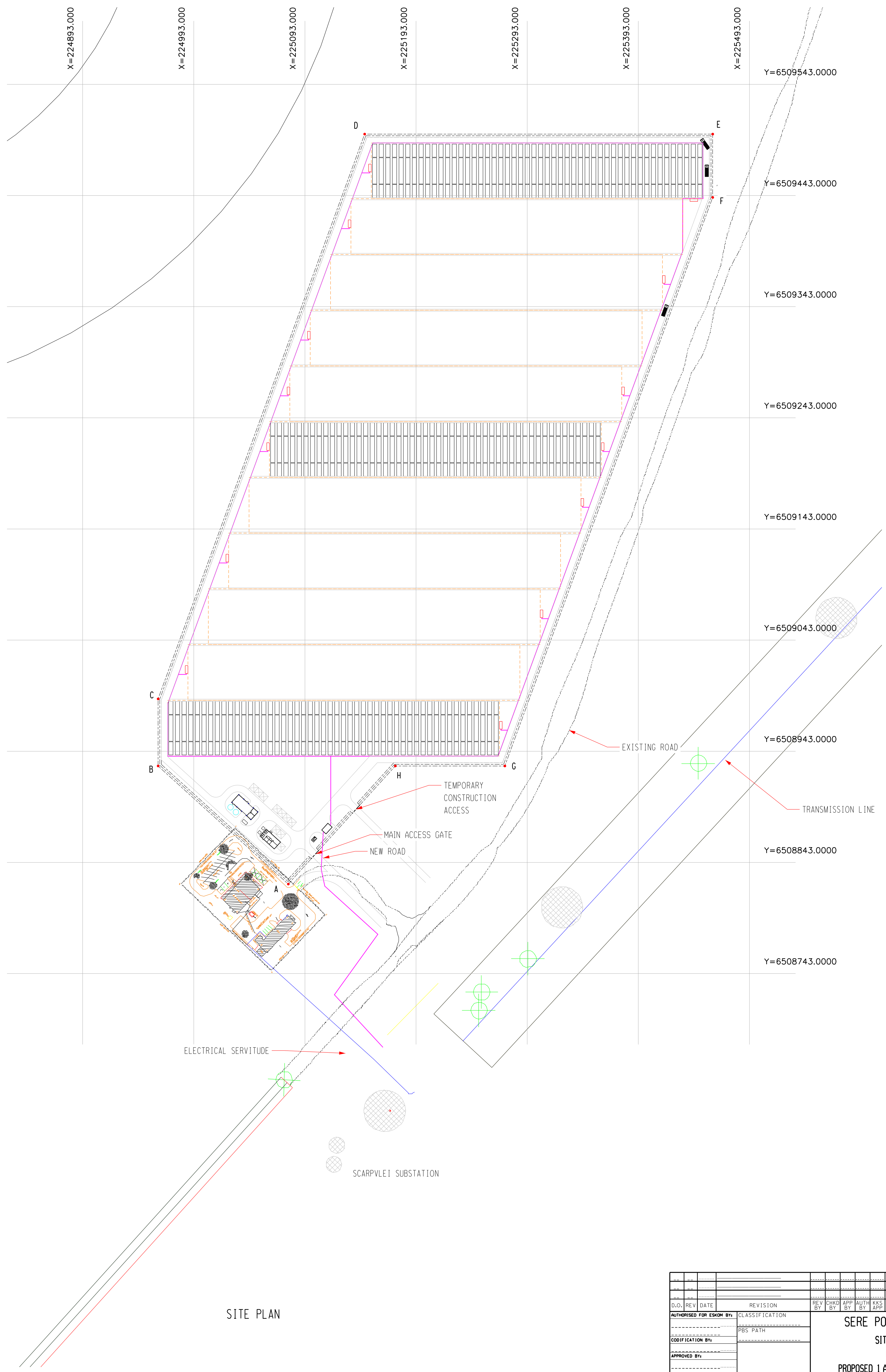
B	224960.9175	6508929.7561
C	224960.9175	6508990.1317
D	225146.7228	6509498.2519
E	225459.8847	6509498.2519
F	225459.8847	6509441.2569
G	225272.8434	6508929.7561
H	225174.2936	6508929.7561



SITE PLAN

D.O.	REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
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AUTHORISED FOR ESKOM BY:

CODIFICATION BY:

APPROVED BY:

CHECKED BY:

CREATED BY: W MOSES 2022-06-22

SCALE -----

CLASSIFICATION

PBS PATH

Eskom

ESKOM HOLDINGS SOC Ltd
REG No 2002/015527/30

SERE POWER STATION
SITE LAYOUT
UNIT 0
PROPOSED 1 AXIS ALTERNATIVE B
SOLAR FARM

ESKOM DRAWING NO 0.95/xx | SHT 01 | REV 00

SIZE A0L

DRAWING CLASSIFICATION: CONTROLLED DISCLOSURE

Eskom	Report	Asset Management

Title: **Concept Design for Sere Solar PV Plant Phase 1a**

Unique Identifier:	**474-12571**
Alternative Reference Number:	**N/A**
Area of Applicability:	**Generation**
Documentation Type:	**Report**
Revision:	**1**
Total Pages:	**93**
Next Review Date:	**N/A**
Disclosure Classification:	**CONTROLLED DISCLOSURE**

APPROVED FOR AUTHORISATION
GENERATION ENGINEERING
DOCUMENT CENTRE ☎ X4962

Compiled by	**Functional Responsibility**	**Authorised by**
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M. Mtshali	**K. Govender**	**B. van der Merwe**
Senior Technologist: Asset Management Mechanical	**Chief Engineer: Peaking**	**Peaking Asset Management Manager (Acting)**
Date: 20 September 2021	Date: 2021-09-20	Date: 2021-09-30

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The Eskom Integrated Long Term Plan and the Eskom Corporate Plan sets up the organisation for growth and maps out a low carbon future in a post-coal environment. The plan describes Eskom's participation in renewable energy and other technologies to deliver on opportunities that will add generating capacity and in turn aid in alleviating system constraints, while also pursuing a low carbon future.

The hybridisation of the existing Sere Wind Farm was identified as one of the projects that could achieve these objectives. Sere Wind Farm is a 105.8 MW wind facility located near Vredendal in the Western Cape and entered commercial operation on 31 March 2015. To address the urgent need for additional generating capacity, it has been proposed that PV technology be installed at the Sere Wind Farm site in phases. The following phased approach has been proposed:

- Phase 1a – Photovoltaic plant less than 20 MW capacity, occupying less than 20 ha land area
- Phase 1b – 50 MW Photovoltaic
- Phase 2 – 530 MW Photovoltaic

The execution of the proposed phases will result in the Sere PV Plant reaching total capacity of approximately 600 MW. This document is applicable for phase 1a of the programme. Due to the urgent need for additional generation capacity and the tight time constraints for the project, phase 1a is required to not trigger the full scoping and detailed Environmental Impact Assessment (EIA). This requires that phase 1a adhere to environmental basic assessment technical requirements of a plant capacity that is less than 20 MW and occupies land that is less than 20 ha.

2. SUPPORTING CLAUSES

2.1 SCOPE

2.1.1 Purpose

This document describes the conceptual design requirements for the Sere Solar PV Phase 1a project, which will inform the functional specification for the Solar PV facility.

2.1.2 Applicability

This document shall apply to the Sere Solar PV Phase 1a project.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

[1] 474-12534 Stakeholder Requirements Definition for Sere Solar PV Plant Rev 2

[2] 480/2 – Required Operational Capability Report: Sere PV Plant – Phase 1a

[3] 240-147711627 – Operational Plan for Small Scale and Utility Scale Solar PV Plants in Northern Cape

[4] Engineering Work Request (EWR) - Sere Solar PV Plant

[5] ISO 9001 Quality Management Systems.

[6] 240-53113953 Manage Engineering Accountability Procedure

[7] 240-53114026 Project Engineering Change Management Procedure

[8] 240-53114002 Engineering Change Management Procedure

[9] 240-50317699 Manage Technical Queries Procedure

[10] 240-53114194 Control of Non-conforming Product

[11] 240-53113685 Design Review Procedure

[12] 240-48929482 Tender Technical Evaluation Procedure

[13] 240-49910527 Procedure for Plan and Select Technologies

[14] 240-76992014 Project/Plant Specific Technical Documents and Records Management Work Instruction.

2.2.2 Informative

[15] A. Pandarum, 2019. Price parity of solar PV with Storage? 27th AMEU Technical Convention

[16] International Finance Corporation – Utility-Scale Solar Photovoltaic Power Plants – A Project Developers Guide, 2015

[17] Benchmarking Utility-Scale PV Operational Expenses and Project Lifetimes: Results from a Survey of U.S. Solar Industry Professionals – Wiser, R., Bolinger, M. and J. Seel. 2020

[18] NREL, 2020. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020

[19] NREL, 2018. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018

2.3 DEFINITIONS

Definition	Description
Annual average GHI	Global Horizontal Irradiance (GHI) is the total irradiance from the sun on a horizontal surface on Earth. It is the sum of diffuse horizontal and direct irradiance, after accounting for the solar zenith angle of the sun.
Annual energy generation	AC electrical output of the system. This is electricity available for the grid, building load, or battery storage. When curtailment, i.e. clipping, is implemented, this curtailment losses are deducted from the annual energy generation total.
Array	An array is the PV plant configuration. The number of modules per string and strings in parallel constitutes an array. In this study, the PV plant or array is the same. In bigger plant designs, you can have multiple arrays represented in the PV plant.
DC/AC ratio	The ratio of total inverter DC capacity to total AC capacity.
Energy yield	The ratio of the system's annual AC electric output in Year one to its nameplate DC capacity. *Energy Yield = Net Annual Energy ÷ Nameplate Capacity.*
Irradiance	Irradiance is the radiant flux, i.e. power or solar energy, received by a surface per unit area. The unit of irradiance is measured in watt per square metre (W/m^2)
Module	The module converts solar irradiance into electric power. The module is the area within a PV panel that fulfil this function.
Nameplate DC capacity	Maximum DC power output of the plant at the reference conditions. *Nameplate Capacity (kWdc) = Module Rated Power (Wdc) × 0.001 (kW/W) × Total Modules*
Net Annual Energy	The total annual electric generation in the first year of operation.
Nominal energy on plane of	Total radiation incident on the entire array before shading and soiling

Definition	Description
array	factors are applied for all sub arrays.
Performance ratio	The performance ratio is a measure of the PV annual electric generation output in AC kWh compared to its nameplate rated capacity in DC kW, taking into account the solar resource at the system's location, and shading and soiling of the array. *Performance ratio = annual energy (kWh) ÷ (annual POA total radiation (nominal) (kWh) × module efficiency (%))*
Plant Efficiency	Annual energy generation of plant over nominal energy received on plane of array, i.e. PV module surface area
POC	The electrical node on a transmission/Dx system where a customer's assets are physically connected to the transmission /Distribution network service provider's assets.
PV Block	A PV block is a single 1 MW PV plant consisting of a single transformer and inverter, with the associated PV modules and structures, combiner boxes, switchgear, and protection etc.
PV system, PV plant	A power system designed to supply usable electrical power by means of photovoltaics, consisting of an arrangement of PV modules, inverters, transformers, cabling, and other electrical accessories
Typical meteorological year	Typical meteorological year (TMY) is a collation of selected weather data for a specific location, listing hourly values of solar radiation and meteorological elements for a one-year period. These values are generated from hourly data from a much longer period, (normally 10 years or more). The hourly data is specially selected so that it represents the range of weather phenomena for the location in question, while still providing annual averages that are consistent with the long-term averages for the location in question.

2.3.1 Disclosure Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC or ac	Alternating current
AIS	Air Insulated Switchgear
BESS	Battery Energy Storage System
C&I	Control and Instrumentation
CAPEX	Capital Expenditure
CCTV	Closed Circuit Television
CdTe	Cadmium Telluride
CIGS	Copper Indium/Gallium/Selenite
CIS	Copper Indium Selenide
CMS	Control and Monitoring System

Abbreviation	Description
CPU	Central Processing Unit
c-Si	Crystalline silicon
DC or dc	Direct current
DMZ	Demilitarised zones
EIA	Environmental Impact Assessment
EMI	Electromagnetic Interface
EPC	Engineering, Procurement and Construction
GHI	Global Horizontal Irradiation
GIS	Gas Insulated Switchgear
GPS	Global Positioning System
GTI	Global Tilt Irradiation
HAP	Hourly Analysis Program
HDMI	High definition multimedia interface
HMI	Human Machine Interface
HV	High Voltage
HVAC	Heating, Ventilation and Air-Conditioning
IEC	International Electrotechnical Commission
IM	Information Management
IP	Internet Protocol/Ingress Protection
IT	Information Technology
kW	Kilowatt, AC power of the Plant
kWp	Kilowatt Peak, DC power of the Plant
LAN	Local Area Network
LCOE	Levelised Cost of Energy
LPU	Large Power User
LV	Low Voltage
MV	Medium Voltage
MWp	Megawatt Peak, DC Power of the Plant
NTP	Network Time Protocol
O&M	Operating and Maintenance
OHL	Overhead Line
OHS	Occupational Health and Safety
OPC	Open Platform Communications
OPEX	Operational Expenditure
OS	Operating System
OT	Operational Technology

Abbreviation	Description
PAT	Provisional Acceptance Test
PDS	Plant Data System
PILC	Paper Insulated Lead Covered
PLC	Programmable Logic Controller
POA	Plane of Array
PoC	Point of Connection
PV	Photovoltaic
PVGIS	Photovoltaic Geographical Information Systems
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SAM	System Advisor Model
SANS	South African National Standards
SCADA	Supervisory Control and Data Acquisition
SLD	Single Line Diagram
SPD	Surge Protection Device
SPR	Self-Powered Protection Relay
SRD	Stakeholder Requirement Definition
STC	Standard Test Condition
STP	Shielded Twisted Pair
TMY	Typical Meteorological Year
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
VPN	Virtual Private Network
WULA	Water Use Licence Approval
XLPE	Cross Linked Polyethylene
ZAR	South African Currency, Rand

2.5 ROLES AND RESPONSIBILITIES

Compiler: Responsible to compile the document and to ensure that the content is integrated to reflect the requirements of every stakeholder forming part of this project.

Functional Responsibility: The Functional Responsible person is responsible to approve the content of the document and assure its correctness before the document is submitted for authorisation.

Authoriser: The document Authoriser is responsible to ensure that the correct processes were followed in developing this document and that the relevant stakeholders have been involved. The Authoriser also reviews the document for alignment to business strategy, policy, objectives and requirements. He/she shall authorise the release and application of the document.

2.6 PROCESS FOR MONITORING

The document shall be utilised as a baselined concept design document. Should the document require modification, the Project Engineering Change Procedure [7] shall be adhered to.

2.7 RELATED/SUPPORTING DOCUMENTS

N/A

3. CONCEPT DESIGN

3.1 SCOPE OF CONCEPT DESIGN

The scope of the concept design study covers several systems necessary for the design of the solar PV plant and summarised as follows:

- Solar resource, modelling and energy yield assessment
- PV layout development
- AC and DC Electrical reticulation design
- Control Monitoring System (CMS) Network Design requirements
- HVAC system requirements
- Fire Detection and Protection requirements
- Water supply and reticulation design
- Sewerage and waste removal services
- Civil and structural designs
- CAPEX, OPEX Estimation
- LCoE Estimation

3.2 CONCEPT DESIGN OBJECTIVES

The main objective of the concept design study is to assess and recommend feasible technical design solutions that are considered suitable for a solar PV plant that will assist meeting the following project requirements:

- Due to the urgent need for additional generation capacity and the tight time constraints for the project, phase 1a is required to not trigger the full scoping and detailed EIA. This requires that phase 1a adhere to environmental basic assessment technical requirements of a plant capacity that is less than 20 MW and occupies land that is less than 20 ha.
- Provide sufficient level of conceptual design that adequately informs the functional specification that will be issued to the market.

It is assumed that the Sere PV phase 1a facility will be procured utilising an EPC/Turnkey approach. This concept design is aimed at exploring the potential solution set, understanding the technical constraints and boundaries, and thereby allowing for the development of a functional specification to adequately describe the project requirements to potential Bidders. This concept design will therefore not exclude/eliminate options that could potentially meet the defined project requirements.

3.3 SYSTEM DESCRIPTION

The conceptual design for the Sere Solar PV phase 1a plant evaluates and assesses the following scenario:

- Option 1: PV plant size of 19.5 MW
- Option 2: PV row-to-row optimised design
- Option 3: Maximised energy yield
- Option 4: Maximised energy yield with single axis tracking

The project also includes scope of work performed by Others, such as the Security, Information Technology (IT) and Telecommunications designs. These are not included in this concept design report.

The PV plant has interfaces to only Security, Information Technology, and Telecommunications. There are no interfaces or integration between the PV and Battery Energy Storage System (BESS) project. The PV plant and BESS operate independently from each other.

The following external interfaces have been identified:

- IT interface via firewall/DMZ to OT network for remote monitoring of the PV plant
- IT interface to business network for day-to-day work activities, i.e. office LAN, printer etc.
- Security access control, perimeter fencing, CCTV
- 33 kV intermediate busbar to accommodate PV plant outgoing AC cables
- Where required look at interfaces with local municipalities for water supply and firefighting support and approval of fire protection/detection rational designs based on local bylaws.

The PV plant will be required to have remote monitoring and control. When the O&M contract is placed upon commissioning of the plant, remote monitoring and control will be required from the contractor's control centre. This would require an architectural design and topology from IT to ensure Eskom's Cyber Security, required firewalls and secure VPN are catered for.

- An IT/OT interface with the required DMZ and firewalls is required for the plant to achieve remote control and monitoring.
- The existing onsite office is expected to have access to the business network.
- The IT architectural design and topology for the project is done by others.
- A security risk assessment for the entire site has not been concluded. Physical Security Design for the project is done by others.

3.4 SYSTEM ARCHITECTURE

A Solar PV Plant generates electrical power by converting solar radiation through a process known as the photovoltaic effect.

The Solar PV Plant consists of:

- PV modules that are connected in series to form strings. These strings are further combined via combiner boxes to form PV arrays.
- PV ground mounting structures and foundations used to fix the PV modules to the ground at the appropriate orientation to the sun.
- Inverter and transformer cabins which house the inverters that converts DC electricity from the PV arrays to AC electricity at grid frequency, and transformers to step-up the voltage as determined by the selected point of connection.
- Solar PV plant power collection switchgear, auxiliary transformers, and battery tripping units.
- AC cabling that will connect the Solar PV plant to the selected point of connection.

- Infrastructure and associated utilities such as roads, storm water infrastructure, security fence, buildings, and meteorological measuring stations.

The three main components that form the backbone of a PV plant are PV modules, PV ground mounting structures, and inverters. These are further described in the following sections.

3.4.1 PV Modules

PV modules are made up of PV cells that generate electricity on exposure to solar radiation. PV technologies can be divided into different types depending upon the materials used in the modules. Generally, two different concepts for generating energy by means of PV technology are commercially available on the market; crystalline silicon based and thin film-based PV technology. Both use direct and diffuse components of solar irradiation.

Crystalline silicon (c-Si) based Solar PV modules can be divided into two main categories: mono and poly crystalline silicon. Mono crystalline silicon PV modules are based on mono crystalline silicon cells and are the most efficient modules to generate electrical energy from solar energy.

Thin film-based PV modules can be amorphous silicon, Copper Indium Selenide (CIS), Cadmium Telluride (CdTe) and Copper Indium/Gallium/Selenite (CIGS), depending on the type of material used. Thin film module technology used to be cheaper than silicon crystalline but with a lower efficiency. This gap is significantly reduced in the current PV market due to decreases in c-Si module prices in recent years.

Some recently introduced thin-film technologies can reach efficiencies comparable with poly silicon technology. Aside from the cost advantage, thin film technology has two further benefits to be considered: the more effective use of diffuse light, as well as mostly more favourable temperature related performance compared to crystalline modules.

From the thin film technologies, amorphous Silicon (a-Si), Copper Indium Selenide (CIS) and CIGS are not preferred due to their large footprint, i.e. land usage that would be required. Furthermore, these modules are not easily available on the market and have a very limited track record.

For c-Si modules, the Poly-crystalline types are preferred, while for the thin film modules, CdTe types are preferred. The advantages of these types of PV modules are listed in Table 1.

Table 1: Preferred PV module types - Advantages

Poly-crystalline PV modules	Cadmium Telluride PV modules
• Good efficiency • Small footprint (land usage) • Extensive track record • Low unit cost (per Wp installed) • Market leader • Extensive list of suppliers	• Good efficiency (now comparable to poly-crystalline) • Good performance in hot weather locations • Extensive track record • Market available • Low unit cost (per Wp installed)

3.4.2 Ground Mounting Structures and Foundations

PV mounting options include fixed tilted mounting systems and tracking systems. Tracking systems can be single axis or dual axis systems. Figure 1 illustrates these different types of mounting systems.

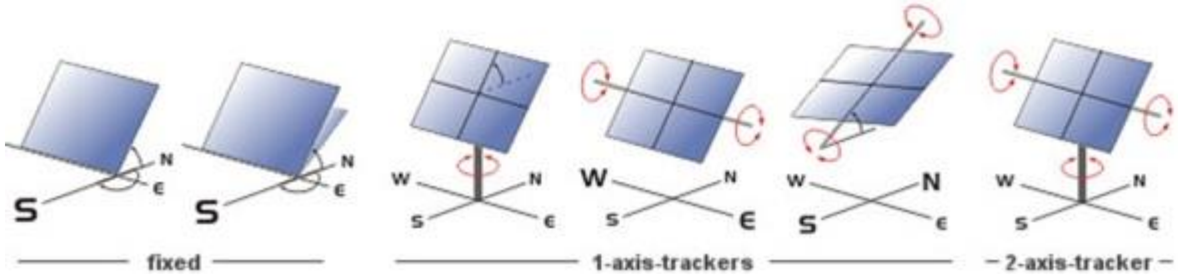


Figure 1: Types of Mounting Systems

The simplest installation for large scale free field mounted PV systems is fixed mounted systems, where groups of PV modules, i.e. PV arrays, are mounted on a structure with fixed slope or inclination and fixed azimuth, generally due north in the southern hemisphere. These structures are usually metallic. Figure 2 illustrates examples of fixed mounting structures.

Figure 2: Examples of Fixed Mounting Structures

For maximum annual energy production, the optimum inclination with respect to horizontal plane and the module plane is generally determined in accordance with the respective latitude of the site. For PV plants located in South Africa, the optimal inclination angle or tilt is generally between 20° and 30°, depending on the exact location.

Fixed mounted structures are considered as very robust and mostly maintenance free solutions. The use of these systems usually allows the plant layout to be easily adaptable to the terrain.

Single-axis tracking systems have recently become widely implemented in utility-scale applications due to their decreasing costs, and the desire for maximising energy production from PV facilities, thereby maximising profits. Tracking systems make financial sense when the energy generation yield gain over fixed-tilt applications outweighs the capital and operational expense of the system. Single-axis trackers generally rotate PV modules from east to west throughout the day, about a fixed axis which is parallel to the ground (other variations do exist). This allows the PV modules to approximately follow the sun's movement from the morning to evening across the sky and can result in increased energy yield depending on the site and other factors.

Detailed geotechnical investigations will be required to determine the geotechnical parameters and to inform the foundation design of the mounting structures (fixed-tilt or tracking systems).

3.4.3 Inverters

The inverter is a key component of the plant when it comes to reliability and efficiency. The three most common inverter-module configurations in PV systems are central inverter, string inverter and module integrated inverter, as shown in Figure 3.

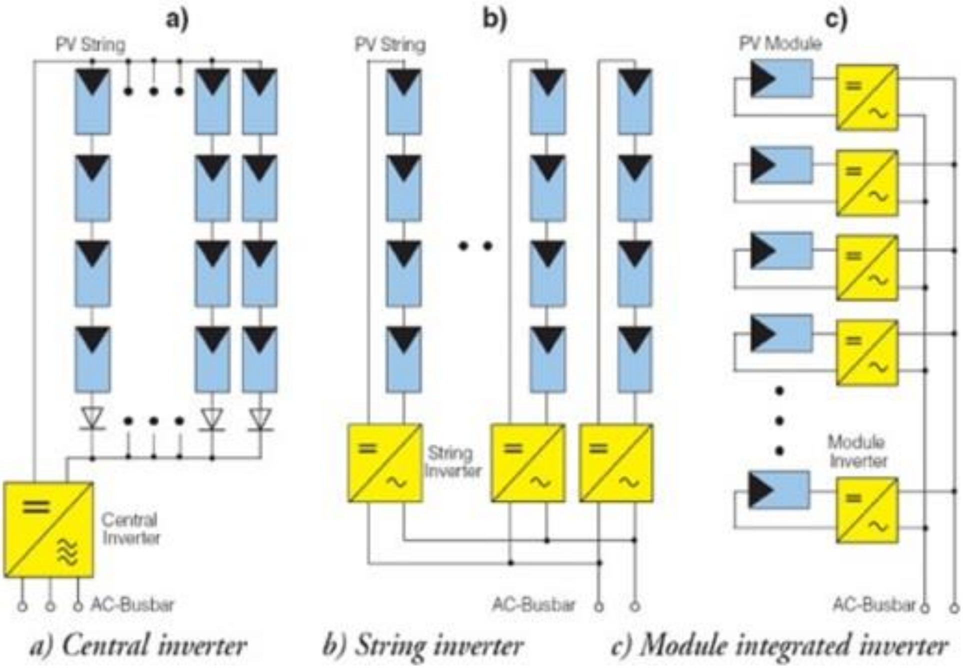


Figure 3: Inverter Configuration Types

Module integrated inverters or micro inverters use a single inverter for each PV module. This configuration minimises shading losses and module mismatch losses in a string, however, this solution is relatively expensive for large scale grid tied power plants, due to the number of module inverters required.

Mini central or string inverters use a single string or group of strings as input to the inverter. The string inverter concept is most suitable on complex sites, where different shadings or orientation of the strings occur. String inverters tend to have higher cost than central inverters and will also have higher AC cable loss than a plant with central inverters.

Central inverters aggregate a large number of strings or all strings of a PV array, several hundred kWp, through DC combiner boxes. Central inverters are generally characterised by a lower cost per kW. Central inverter concepts are commonly used in utility scale PV plant. Central inverters also ease operation and maintenance as the number of units required for a given PV plant capacity is significantly lower than for the other configurations.

3.5 SITE TECHNICAL ASSESSMENT

3.5.1 Site Location

The solar PV plant is located within the Sere Wind Farm. The site is located on portions of the farms Olifants River Settlement 617 and 620, and Gravewaterkop 158 portion 5 situated on the Namaqualand Coast in the Vredendal District, about 14km west of Koekenaap in the north of the Western Cape Province as seen below.

Figure 4: Sere Wind Farm

As per the limitations of the environmental basic assessment, the development of the solar PV plant should be less than a 20 ha footprint. The solar PV plant will be accessed from the R363 road.

The site boundary co-ordinates are summarised below (these are subject to change based on the environmental basic assessment and the final design configuration):

Table 2: Site co-ordinates

Co-ordinate	Latitude (º)	Longitude (º)
A	31.530777	18.111159
B	31.526435	18.111292
C	31.526533	18.115657
D	31.530876	18.115524
Central Point	31.528655	18.113408

3.5.2 Solar Resource Assessment

This section provides an overview on meteorological data and solar resource data analysis at the project location.

South Africa in general has excellent solar resource providing a favourable condition for the development of solar projects. The annual average Global Horizontal Irradiation (GHI), depending upon the regions, varies approximately between 1500 kWh/m^2 and 2400 kWh/m^2, see Figure 5.

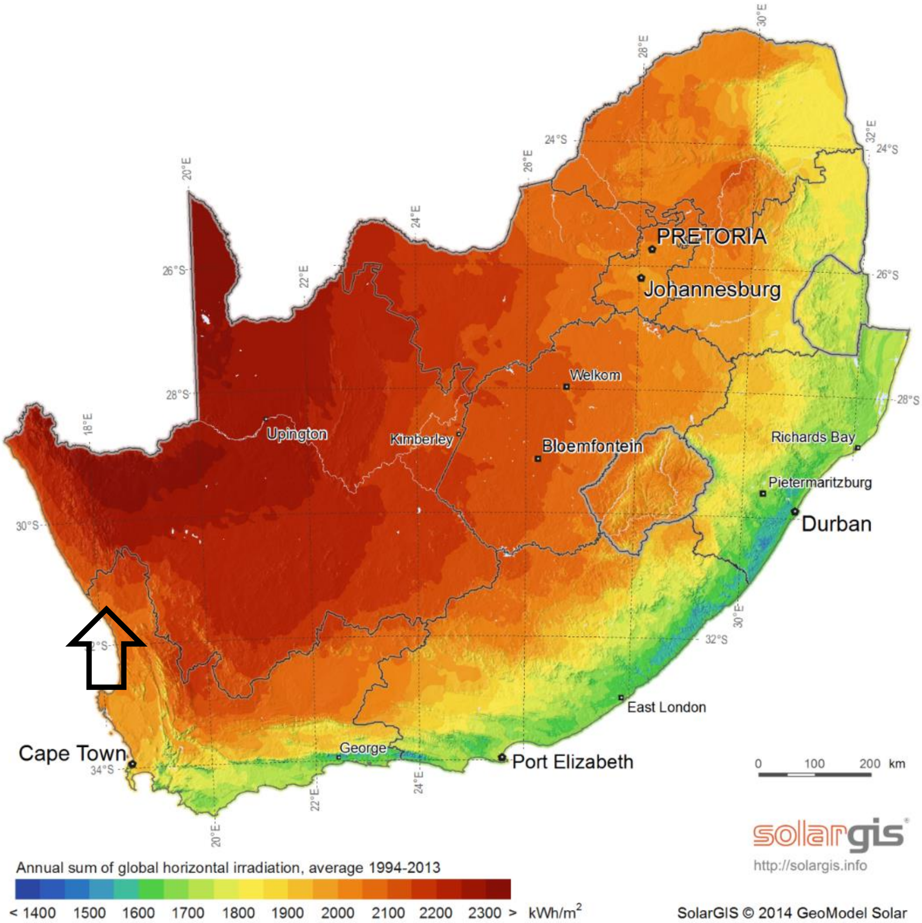


Figure 5: Annual GHI Map – South Africa (Source: CRSES)

The project site has an approximate geographic location of 31°31'43.158" South, and 18°6'48.2688" East, at a height above sea level of 32 m. The site lies in regions of the South Africa with some of the highest solar resource, as shown with an arrow mark in Figure 5. The annual average GHI at the project location can be expected to be between 2000 kWh/m^2 and 2200 kWh/m^2. Table 3 shows the comparison of long term annual average GHI between different data sources at the project location.

Table 3: Summary of Long-Term Average Annual GHI

Data Base	Data Source	Data Spatial Resolution	Period	GHI [kWh/m²]
HelioClim	Satellite	2.5 km × 2.5 km	1990 - 2006	1891
PVGIS	Satellite	1 km × 1 km	2005 - 2016	2161
SolarGIS	Satellite	Up to 90 m × 90 m	1994 - recent	2091

The long-term average GHI derived from different meteorological data sources mentioned in the above table have a maximum deviation of approximately 12%. This result indicates that the long term annual average GHI at the solar PV plant lies between 1891 kWh/m^2 and 2161 kWh/m^2. This deviation could be as a result of the spatial resolution of HelioClim data being larger than the PVGIS and SolarGIS data resolution or the fact that although HelioClim has data dating back from 1990, the data available for the annual average calculation is from 2004 to 2006. SolarGIS and PVGIS have a longer term in which the annual average was calculated. However, the deviation between PVGIS and SolarGIS data is approximately 3%.

For concept designs, Photovoltaic Geographical Information Systems (PVGIS) was used to provide Typical Meteorological Year (TMY) data for the System Advisor Model (SAM) software simulation and is also used for the energy yield estimation.

PVGIS uses long-term monthly averages of solar irradiation to calculate solar radiation and PV energy outputFigure 6. This is done by simulating how the solar radiation and PV power varies during a "typical" day in each month. The advantage of this method is that the calculations are much faster than calculating a full multi-year time series and that much less data needs to be stored.

PVGIS calculates solar radiation and PV energy output using hourly values of solar radiation and other climatic parameters over a period of several years (2005-2016). This innovation helps to overcome the problems listed above.

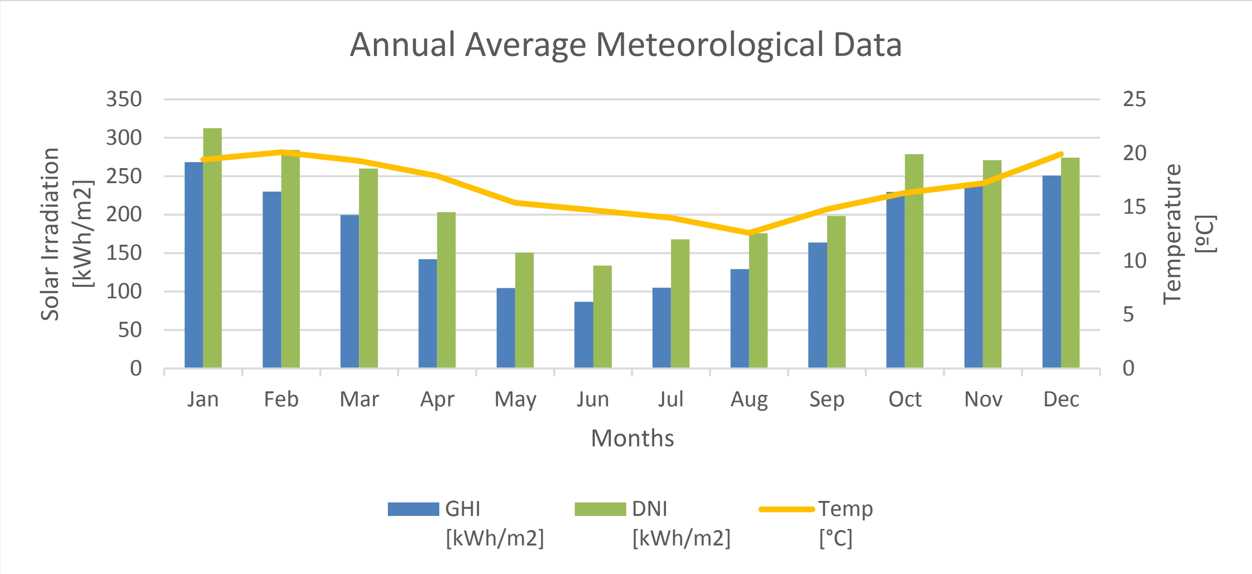


Figure 6: Long Term Average Meteorological Data (2005-2016)

The following table shows the monthly average summary of meteorological data to be used for the project.

Table 4: Monthly Average Summary of Meteorological Data for Sere Solar PV Site

Month	GHI (kWh/m^2)	DNI (kWh/m^2)	GTI (kWh/m^2)	Temp (º C)
January	268	242	313	19,4
February	230	230	284	20,1
March	200	229	260	19,3
April	142	188	203	17,9
May	104	152	151	15,4
June	86	135	134	14,7
July	105	163	168	14,0
August	129	177	176	12,6
September	164	195	198	14,8
October	230	240	279	16,3
November	241	224	271	17,2
December	251	221	274	19,9

3.5.3 Meteorological Station

The site will have a meteorological station installed to measure onsite meteorological and weather data. The installation of any meteorological station should not result in shading of the PV array. The site meteorological station should comprise of the following:

a. Two (2) high accuracy calibrated solar reference cells installed on the module plane of array (POA) with the same technology and type as installed PV modules. The calibration of the reference cell is performed according to IEC 60904-2: Photovoltaic device - Part 2: Requirements for reference solar devices.
b. Two (2) thermal sensors (Pt 100 class B according to IEC 60751) to measure module surface temperature with a measurement resolution up to ± 1°C at the back sheet.
c. One (1) shielded ventilated thermocouple to measure the ambient temperature with a measurement accuracy of ±1°C (Pt 100 class B according to IEC 60751).
d. One (1) wind speed and wind direction sensor mounted on a 10 m mast.
e. One (1) relative humidity sensor, and
f. One (1) rain gauge.

In addition to the site meteorological station, the following measuring equipment will be installed at every PV block:

a. Two (2) horizontally mounted and completely unshaded, calibrated pyranometers to measure the global horizontal irradiation according to Secondary Standard as stipulated in ISO 9060. One of the pyranometers to be installed in the Plane of Array.

3.5.4 Weather Conditions

The following section is a high-level summary of the weather data recorded at the Sere Wind Farm meteorological station from January to December 2020. It should be noted that this weather data is incomplete and has sections where the data was not recorded due to power interruptions, faulty or no equipment, or lack of site services. Conclusions taken from the following sections are preliminary estimations. More rigorous analysis with larger datasets would be required to minimise the risks and will be conducted during the detailed design phase.

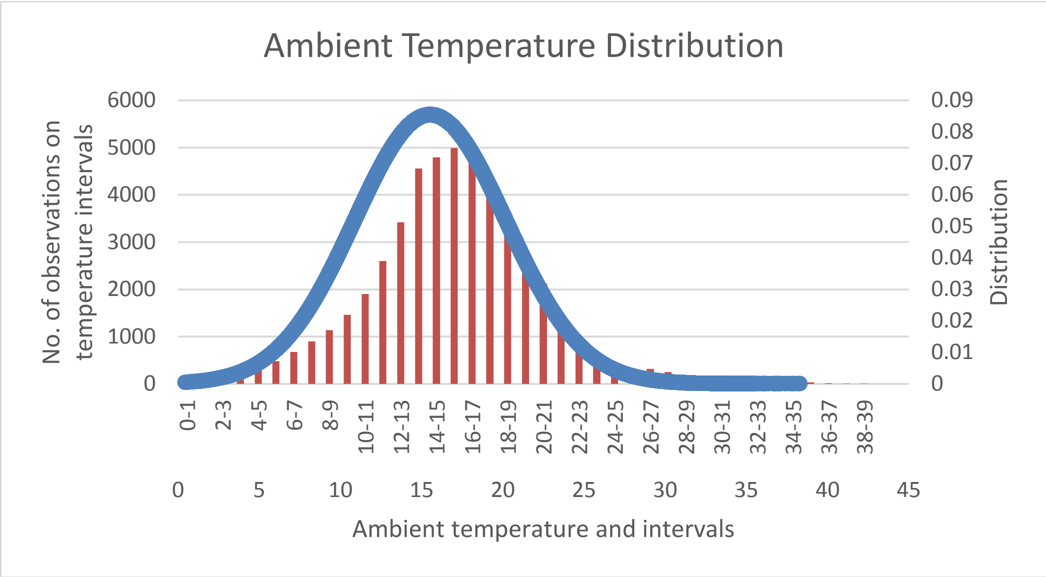
3.5.4.1 Ambient Temperature

Table 5 indicates the average, standard deviation, maximum and minimum temperatures that were measured during the analysis period. The lowest temperature measured during the analysis period was 0.4 ^{0}C with the maximum being 38^{0}C.

Table 5: Ambient Temperatures Statistical Values

Date	Average	Standard deviation	Minimum	Maximum
January	18.19	2.46	12.19	32.15
February	18.51	2.29	12.57	25.64
March	17.81	3.74	6.40	38.32
April	17.12	4.82	6.75	36.66
May	15.33	5.68	4.20	36.27
June	13.53	4.92	1.93	31.02
July	13.84	5.36	3.01	31.25
August	12.03	4.40	0.45	31.98
September	13.69	4.44	2.26	33.87
October	14.75	3.26	5.69	31.01
November	16.71	3.85	7.31	37.95
December	17.31	2.52	9.13	26.03
Annual	**15.54**	**4.67**	**0.45**	**38.32**

Figure 7 illustrates the range the ambient temperature varied during the measurement period. The ambient temperature frequency distribution is also shown.



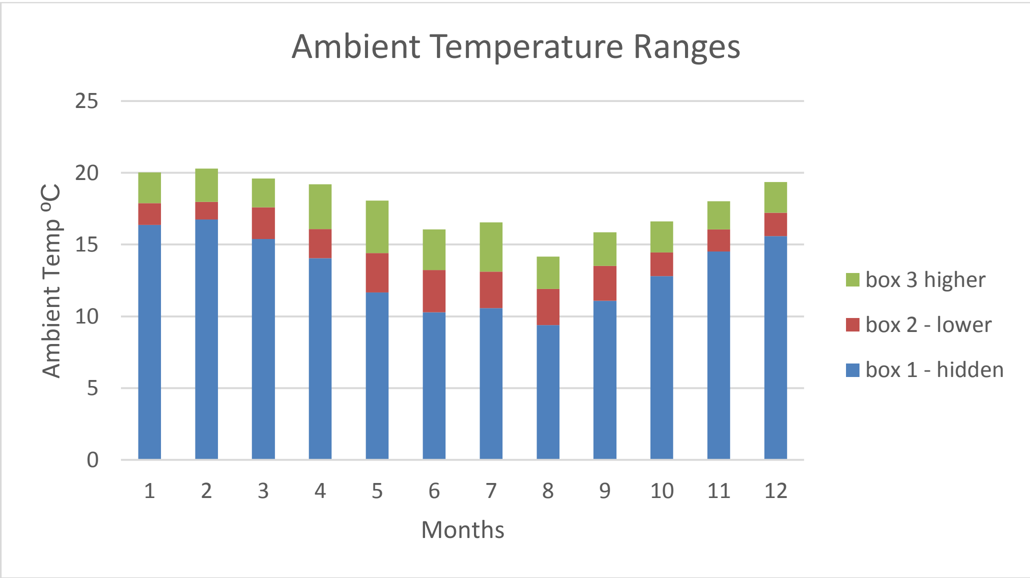


Figure 7 : Ambient temperature graph

3.5.4.2 Wind Speed

Table 6 indicates the average, standard deviation and maximum wind speeds that were measured during the analysis period. The maximum wind speed measured during this period was 21.1 m/s. The high wind speeds measured are consistent with the fact that the site is in an area in South Africa with excellent wind resource.

Table 6: Wind Speed Statistical Values

Date	Mean	Standard deviation	Maximum
January	6.03	2.49	13.49
February	5.10	2.32	11.66
March	5.49	2.85	15.47
April	5.91	2.82	17.72
May	4.77	2.39	16.79
June	6.08	4.20	20.20
July	6.77	4.13	20.41
August	6.24	3.18	21.10
September	6.41	3.18	18.15
October	6.14	2.84	15.26
November	7.08	3.17	18.73
December	6.32	2.90	15.83
Annual	**6.11**	**3.18**	**21.10**

Figure 8 illustrates the wind speed frequency distributions.

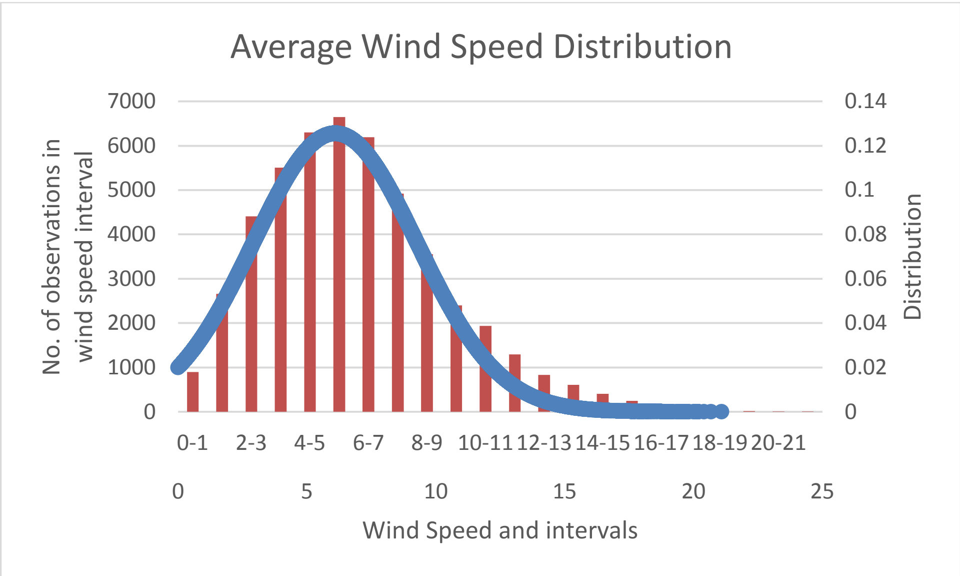


Figure 8: Wind speed graph

3.5.4.3 Wind Direction

Figure 9 illustrates the predominant wind directions based on the measurements recorded. It is noticed that in 2020 the wind seems to blow predominantly from south-south-west directions.

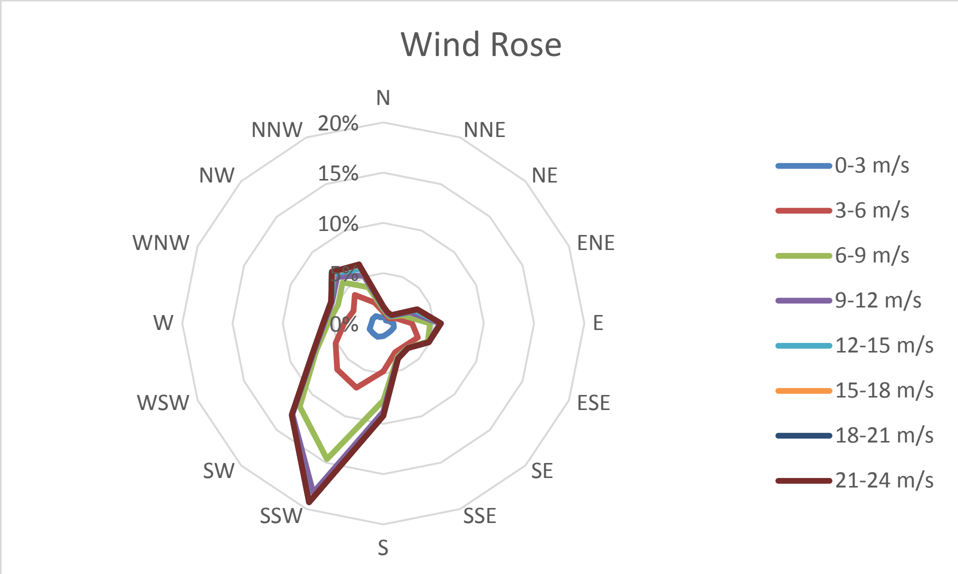


Figure 9: Wind Rose

3.5.4.4 Rainfall

Table 7 indicates the amount of rainfall that was measured for each month of 2020. The highest amount of rainfall measured was approximately 77.37 mm in July. The lowest was in February with a measurement of approximately 2.64 mm. The total annual rainfall for 2020 was measured to be approximately 448.75 mm.

Table 7: Annual total rainfall

Date	Total rainfall (mm)
January	55.91
February	2.64
March	11.47
April	33.82
May	20.02
June	58.27
July	77.37
August	71.83
September	35.08
October	55.64
November	11.59
December	15.12
Annual	**448.75**

3.6 PV PLANT DESIGN

3.6.1 Simulation Model

The stakeholder's requirements, captured in the SRD, determine the simulation models developed during concept design. Site specific geographical inputs are required for the simulation model, these include geographical location, solar resource, ambient and other weather conditions and PV plant footprint or area constraints. Other operational requirements from stakeholders such as the operating strategy, operational limitations or constraints, O&M requirements and others are specified in the SRD.

The results from the simulation model during concept design inform other disciplines on the requirements of the plant. This include interconnection requirements to evacuate the power, the auxiliary power required for plant operation, water requirements for cleaning of panels (if required) and the overall footprint of the plant.

In addition, the simulation model also further informs the expected performance over the lifetime of the plant. Important performance parameters include the installed capacity of the plant, energy yield, performance ratio, capacity factor and generating profiles. These performance parameters are key in satisfying the stakeholder's requirements and provide the level of confidence of the expected performance of the plant.

The concept design used the simulation software package System Advisor Model (SAM) to design and simulate the PV system.

3.6.2 Design Inputs

The required PV system design inputs are illustrated in Figure 10.

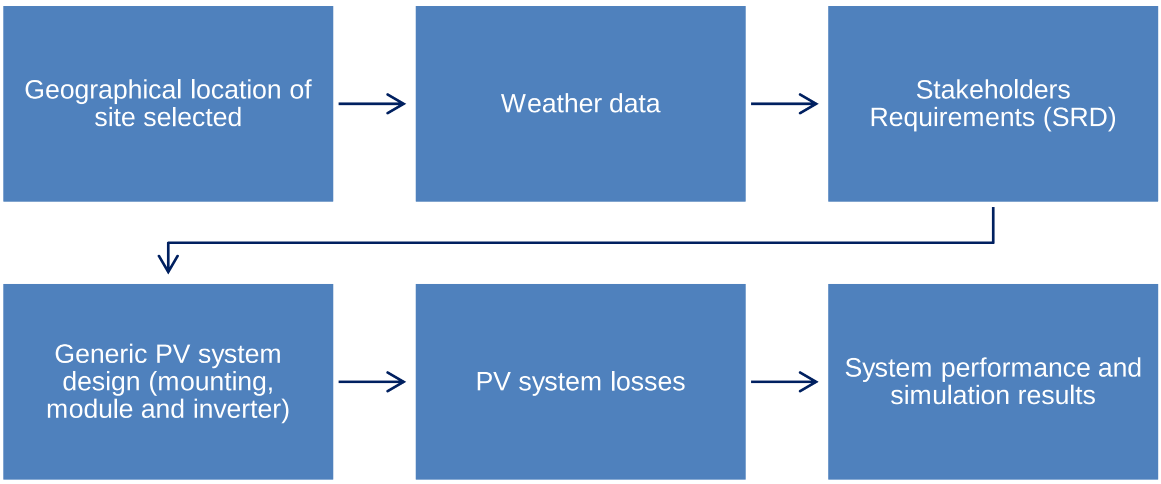


Figure 10: PV system design inputs

3.6.2.1 Geographical location of site

The geographical information is retrieved from Section 3.5.1.

3.6.2.2 Weather data

The solar resource assessment is discussed in Section 3.5.2. The TMY dataset used in the simulation model is retrieved from PVGIS.

3.6.2.3 Stakeholder Requirements

The aim of the project is to accelerate the implementation of PV at the Sere Wind farm site. Therefore, the PV plant design should remain within the envelope covered by an Environmental Basic Assessment, and not trigger the lengthy processes required for a full Environmental Impact Assessment.

The stakeholder requirements are considered in the development of the simulation model:

- The PV plant footprint should be less than 20 ha (this includes supporting infrastructure, internal roads and site boundary fencing and roads)
- The PV installed capacity should be less than 20 MW ac
- The interconnection of the PV plant to utilise the existing Sere Wind farm substation
- The combined generation output from the existing Sere Wind Farm and the proposed PV plant not to exceed 105.8 MW
- When observing the evacuation limit of 105.8 MW, generation from Sere Wind Farm to be prioritised, hence PV generation to be curtailed as required
- Annual average Performance Ratio (PR) of 80%
- Operating strategy of PV plant is to maximise plant generation and energy yield
- Plant design minimum life of 25 years

Other stakeholder requirements affecting plant design:

- Minimum maintenance should be considered in design
- PV panels to be cleaned when reference cells difference is greater than 50 W/m^2
- Plant design to consider local environmental conditions, i.e. coastal region imply corrosion protection due to closeness to the coastline, structural design due to high wind speeds, etc.
- Expandability for Phase 1b and Phase 2 of Sere PV Plant to be considered

A request from the project was received to deliver a high-level concept design. The associated risks are captured in Appendix E for excluding the following engineering activities related to simulation model:

- Technology selection of PV module and inverters
- Optimisation of PV model
- Sensitivity analysis on PV plant performance
- Detail on concept design options

3.6.3 Generic PV System Design

The generic PV system design is primarily used for feasibilities studies. During concept design, alternative technology options associated to the PV module, inverter, mounting structures, etc. are considered to optimise the design based on the environmental conditions and/or stakeholder requirements.

To satisfy the project requirements, a high-level concept design is requested which entails the use of the generic PV system design during simulation. The components are as follows:

- **Module Selection**

  The 320 Wp PV module is a multi c-Si module with characteristics shown in Figure 11.

Nominal efficiency	16.8223	%	Temperature coefficients		
Maximum power (Pmp)	319.792	Wdc	-0.400 %/°C	-1.280	W/°C
Max power voltage (Vmp)	36.8	Vdc			
Max power current (Imp)	8.7	Adc			
Open circuit voltage (Voc)	45.3	Vdc	-0.307	-0.139	V/°C
Short circuit current (Isc)	9.3	Adc	0.047 %/°C	0.004	A/°C

Figure 11: Module characteristics at reference conditions

- **Inverter Selection**

  The inverter selected has a 1 MW capacity, with characteristics shown in Figure 12 and efficiency curve in Figure 13.

Datasheet Parameters

Maximum AC power	1e+06	Wac	Maximum DC voltage	800	Vdc	**Sandia Coefficients**		
Maximum DC power	1.0369e+06	Wdc	Maximum DC current	1389.95	Adc	C0	-2.43682e-08	1/Wac
Power use during operation	4451.37	Wdc	Minimum MPPT DC voltage	585	Vdc	C1	-4e-05	1/Vdc
Power use at night	300	Wac	Nominal DC voltage	746	Vdc	C2	-0.000528	1/Vdc
Nominal AC voltage	690	Vac	Maximum MPPT DC voltage	800	Vdc	C3	-0.000677	1/Vdc
						CEC weighted efficiency	96.922	%
						European weighted efficiency	96.696	%

Figure 12: Inverter characteristics at reference conditions

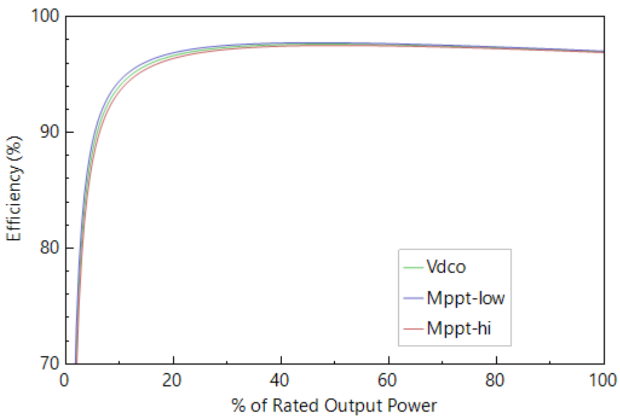


Figure 13: Inverter efficiency curve at reference conditions

- **Mounting Structure**

  The tilt angle for a fixed mounting structure is selected to be 30 degrees, facing north. The 30 degree angle is selected due to the fact that the latitude of the plant is in the most southern parts of South Africa. See Section 3.5.1 on Geographical location of site.

  The row to row distance between each structure is determined on the shadowing effects of adjacent rows. The generic PV system design has a row to row distance of 7.76 m.

The mounting structure accommodates two rows of PV modules, i.e. bottom and top row in a portrait orientation. A total of six strings, i.e. 96 panels are placed per structure. For fixed or static PV systems, the height of the structure can be up to 3.5 m above ground level. Single axis tracking PV systems can have a height up to 6 m above ground level.

Tracking systems in PV plants increase the energy output of the plant by tracking the sun through single-axis (or dual-axis) systems. In large commercial plants the tracking of a PV system can lead to a higher energy yield but increase the effort of maintenance throughout the life of the plant. An additional cost component is associated with the mounting structure, tracking systems, calibration, and control systems. Regular maintenance and monitoring are also required to ensure efficient plant operations.

Single axis tracking is considered for this concept design, as an attempt to increase the annual energy generated by the plant to satisfy the requirement to maximise the energy yield of the plant.

3.6.4 Losses

No additional losses are considered for the simulation model. The generic PV system design losses are a default selection.

3.6.5 System Performance and Simulation Results

For the concept design, various design options will be considered to satisfy the stakeholder requirements. Additional design optimisation and sensitivity analysis will not form part of this concept design as per the project's request. The associated risks are detailed in Appendix E.

3.6.6 Option 1: PV plant size (19.5 MW)

The initial project objective, referenced as Phase 1a for PV installation at Sere, denotes a plant capacity of 19.5 MW (Phase 1a). Although the proposed plant is less than the 20 MW limit required for performing a Basic Environmental Assessment, the footprint area required by the plant exceeds the 20 ha limit and trigger the need to perform a full environmental impact assessment.

Analysing the design requirements of the generic PV model, the total PV module area for a 19.5 MW plant is 138 788 m^2. This translates to a PV plant footprint of 27.7 ha, thus triggering the need for a full environmental impact assessment.

To decrease the PV plant footprint, the row-to-row distance of the mounting structure can be reduced (to a limit), but this trade-off introduces an increase in shadowing losses and decrease in plant performance. The sensitivity analysis as seen on Table 8 shows the row-to-row spacing, PV block footprint, shading, and plant performance ratio.

Table 8: Row-to-row optimisation to reduce PV plant footprint

Row to Row [m]	Road Clearance between structures	PV plant footprint [ha]	Losses Shading (%)	Performance Ratio (PR)
7.77	4.40	27.76	2.54	0.86
6.47	3.11	23.13	3.06	0.85
5.55	2.18	19.83	3.69	0.82
4.85	1.49	17.35	4.45	0.79
4.31	0.95	15.42	5.29	0.76

From Table 8 it is clear that there is a direct relationship between the row-to-row distance of the mounting structures and the footprint of the PV block. To realise a PV plant capacity of 19.5 MW within a 20 ha land parcel (from which up to 2 ha is allocated to fencing, laydown area and other supporting infrastructure), the row-to-row distance needs to be reduced to about 4.85 m. However, the performance ratio of the plant is reduced from 0.86 to 0.79.

This stakeholder requirements states that the minimum performance ratio is to be 0.80. Additional challenges are introduced with only a 1.49 m road clearance between structures, i.e. limiting access for panel cleaning, maintenance, and other O&M activities.

3.6.7 Option 2: PV row-to-row optimised design

Option 1 of the concept design demonstrated that the feasibility of a 19.5 MW PV plant is unlikely to satisfy both the environmental limitations (plant size less than 20 ha) and the stakeholder requirements (performance ratio greater than 80%). Additional O&M constraints are also introduced with a narrow road clearance of about 1.5 m.

Option 2 of the concept design investigates the optimisation of the row-to-row distance to determine a PV plant size that meets requirements specified in the SRD. From Table 8 the performance ratio of the plant is greater than 0.80 where the row-to-row distance is greater than approximately 5.55 m. The road clearance is also more acceptable for O&M activities at approximately 2.18 m.

Based on the information above, the following boundary conditions are set for row-to-row optimisation of the PV plant design:

- PV block footprint not to exceed 16 ha (20 ha less approximately 4 ha required for other supporting infrastructure, laydown area, fencing, internal roads etc.)
- Road clearance greater than 2 m between PV mounting structures for O&M activities
- Operating strategy: Maximise PV plant installed capacity
- Performance Ratio (PR) greater than 0.80

Road clearance between structures

To achieve a road clearance greater than 2 m, the minimum row-to-row distance is calculated to be 5.36 m based on the generic PV model design.

Performance ratio

The performance ratio is affected by the row-to-row distance as it introduces additional shadowing on adjacent rows. With a minimum road clearance of 2 m, i.e. row-to-row distance at 5.36 m, the simulation model indicates that a performance ratio of 0.80 is feasible.

PV block footprint and maximise installed capacity

With the row-to-row distance established by satisfying the road clearance and performance ratio, the maximum installed capacity can be determined. The limiting factor is the 16 ha land availability for the PV block footprint. From the simulation results, a plant capacity of up to 16 MW is feasible, see Table 9.

Table 9: Maximise PV installed capacity on land available

Installed Capacity (MW)	Performance Ratio	Module Area (m^2)	PV Block Footprint (ha)
15	0.80	106 760	14.88
16	0.80	113 878	15.87
17	0.80	120 995	16.86
18	0.80	128 112	17.85
19	0.80	135 230	18.85

3.6.8 Option 3: Maximise energy yield

Although Option 2 demonstrated the maximum PV installed capacity given the specified boundary conditions, the maximum energy yield of the plant has not been established. To maximise the energy yield of a plant design, various design considerations are taken into account. These may include technology options such as various PV modules, inverters, mounting structure orientation or tilt, panel configuration and others.

The aim of maximising the energy yield of a plant is to determine the best technology configuration and plant design to yield maximum energy while minimising energy losses. This concept design only considers the generic PV design model and no further optimisation is performed. Based on the performance results of the simulation model, as per Table 10 to Table 12, the following conclusions are made:

The PV block footprint is the limiting factor for the PV plant capacity that can be installed. In Table 10 an overview of the footprint required per row-to-row distance is shown. The areas less than 16 ha is highlighted for ease of reference.

Table 10: PV block footprint (ha) per row-to-row distance

	Mounting structure row-to-row distance			
MW	**7.77 m**	**6.47 m**	**5.55 m**	**5.36 m**
15	21.35	17.79	15.25	14.75
16	22.78	18.98	16.27	15.73
17	24.20	20.17	17.28	16.71
18	25.62	21.35	18.30	17.70
19	27.05	22.54	19.32	18.68

The annual net energy (kWh) of each configuration (row-to-row spacing and plant capacity) is determined and overlaid with the PV block footprint, shown in Table 11. The maximum energy output decrease with the row-to-row spacing due to the shadowing effects on adjacent rows.

Therefore, the stakeholder requirement to maximise the capacity and energy yield is satisfied with a PV plant capacity of 16 MW with a row-to-row spacing of 5.36 m. This finding is based on the generic PV design model with a fixed mounting structure.

Table 11: PV annual net energy (kWh) per row-to-row distance

	Mounting structure row-to-row distance			
MW	**7.77 m**	**6.47 m**	**5.55 m**	**5.36 m**
15	36 035 500	35 424 600	34 055 600	33 776 200
16	38 437 800	37 786 200	36 325 800	36 027 800
17	40 840 100	40 147 700	38 596 000	38 279 300
18	43 242 500	42 509 300	40 866 200	40 530 900
19	45 644 800	44 870 900	43 136 300	42 782 400

The PV plant performance parameters for various row-to-row distances are shown in Table 12. As previously mentioned, the increased shading losses experienced by narrowing the row-to-row distance affects the plant performance parameters. The parameters in Table 12 are similar for all PV plant capacities as only the row-to-row distance parameter changed. The stakeholder requirement of performance ratio of 0.80 is satisfied.

Table 12: PV plant performance parameter per row-to-row distance

	Mounting structure row-to-row distance			
Parameter	**7.77 m**	**6.47 m**	**5.55 m**	**5.36 m**
Performance Ratio	0.86	0.84	0.81	0.80
Losses Shading (%)	2.61	3.14	3.79	3.96
Energy Yield (kWh/kW)	2006	1972	1896	1881
Capacity Factor AC (%)	27.4	27.0	25.9	25.7

3.6.9 Option 4: Maximise energy yield (single-axis tracking)

To further maximise the energy yield of a PV plant, tracking systems can be implemented in the PV design. However, this has impact on the mounting structure, additional mechanical systems such as motors, control systems and the layout of the plant. For this concept design option, only single axis tracking is considered.

- Single-axis tracking

  The mounting structure is fixed at a tilt angle of zero degrees, i.e. the rotating axis is flat or horizontal (parallel to the ground). The mounting structure rotates about the axis from east in the morning to west in the evening to approximately track the daily movement of the sun across the sky. The configuration also requires a greater footprint than fixed mounted structures at a specified tilt angle. The increase is about 12% more than compared to fixed mounted structures.

There are two types of tracking algorithms or strategies that can be implemented in single-axis tracking:

- Normal tracking

  The azimuth tilt angle towards the sun is the same for every row. Depending on the row-to-row distance and location of the plant, the shadowing losses can have an increased effect.

- Backtracking in single-axis tracking

  Backtracking is a tracking strategy that minimises row-to-row shading. Without backtracking, a one-axis tracker points the modules toward at the sun. For an array with closely spaced rows, modules in adjacent rows will shade each other at certain sun angle. With backtracking, under these conditions, the tracker orients the modules away from the sun to avoid shading. The following diagram, Figure 14, illustrates how backtracking avoids row-to-row shading for a simple array with two rows:

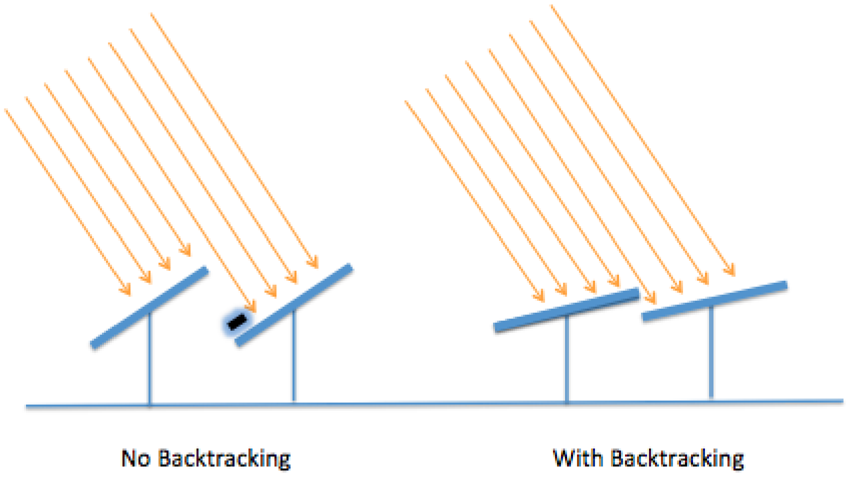


Figure 14: Single-axis tracking strategies

Due to the fact the panels are horizontal on a structure that tilt/track the sun's position, i.e. azimuth angle, the road clearance is affected. This is illustrated in the following table:

Table 13: Effect of row-to-row distance on road clearance between structures

Mounting structure row-to-row distance	7.77 m	6.47 m	5.97 m	5.55 m	5.36 m
Road clearance in between rows	3.88 m	2.59 m	2.09 m	1.66 m	1.48 m

It is noted from

Table **13** that the previous optimised row-to-row distance of 5.36 m no longer allows for sufficient road clearance between the structures, i.e. minimum of 2 m. It was found that a row-to-row distance of about 5.97 m and greater allows for 2 m clearance. Subsequently, the maximum installed PV capacity for single-axis tracking systems should be determined. The results are shown in Table 14. This results in a maximum PV installed capacity of 14 MW with single-axis tracking is achievable.

Table 14: PV block footprint (ha) per row-to-row distance

	Mounting structure row-to-row distance				
MW	**7.77 m**	**6.47 m**	**5.97 m**	**5.55 m**	**5.36 m**
13	18.78	15.65	14.45	13.42	12.97
14	20.23	16.86	15.56	14.45	13.97
15	21.67	18.06	16.67	15.48	14.97
16	23.12	19.26	17.78	16.51	15.96
17	24.56	20.47	18.89	17.54	16.96
18	26.01	21.67	20.01	18.58	17.96
19	27.45	22.88	21.12	19.61	18.96

For the three configurations that satisfy the boundary conditions, that is the minimum clearance between structures of 2 m and having footprint of less than 16 ha, the annual energy yield and performance parameters are determined. The results are shown in Table 15. The plant configuration that generate the most power is a 14 MW plant with backtracking.

Table 15: Performance parameters and annual net energy

Tracking Strategy	**No backtracking**		**Backtracking**	
Mounting structure row-to-row distance (m)	**6.47**	**5.97**	**6.47**	**5.97**
Performance Ratio	0.71	0.69	0.84	0.84
Losses Shading (%)	3.30	3.58	2.44	2.41
Energy Yield (kWh/kW)	2002	1935	2151	2108
Capacity Factor AC (%)	27.4	26.4	29.4	28.8
13 MW Plant Annual Net Energy (kWh)	31 157 200	30 116 300	33 482 500	32 814 700
14 MW Plant Annual Net Energy (kWh)		32 431 900		35 338 900

3.7 PV PLANT DESIGN AND PERFORMANCE PARAMETERS

From the simulation model results, Option 3 and Option 4 of the concept design meet the SRD requirements and practical assumptions:

- PV block footprint not to exceed 16 ha (20 ha less 4 ha required for other supporting infrastructure, laydown area, fencing, internal roads etc.)
- Road clearance greater than 2 m between PV mounting structures for O&M activities
- Operating strategy: Maximise PV plant installed capacity
- Performance Ratio (PR) greater than 0.80

The following sections summarise the PV plant design and performance parameters for:

- 16 MW PV installation with fixed mounting structure (Option 3)
- 14 MW PV installation with single-axis tracking with backtracking (Option 4)

3.7.1 16 MW PV installation with fixed mounting structure

The design parameters for the 16 MW PV plant is set out below in Table 16. The simulation model determines the plant's performance. These parameters are reported in Table 17. A visual representation of the monthly energy generated by the plant is shown in Figure 15.

Table 16: Plant design 16 MW PV with fixed mounting structure

Plant Design	**Value**	**Unit**
PV module rating	320	Wp
PV mounting configuration	2 rows - portrait	
Number of PV modules per string	16	
Number of strings in parallel	3744	
Number of PV modules per mounting	96	
PV module configuration (PV rows)	80	
Number of inverters	16	
PV plant DC capacity	19.15	MWdc
PV plant AC capacity	16.00	MWac
DC/AC ratio	1.2	
Tracking	None - Fixed	
Tilt angle	30	degree
Azimuth angle	North	
Row-to-row distance	5.363	m
Road clearance between structures	2	m
PV plant footprint	15.73	ha

Table 17: Plant performance for 16 MW PV with fixed mounting structure

Performance Parameters		
Installed Capacity	16	MWac
Annual Energy Gross Energy	36 100	MWh/yr
Annual Energy Net Energy	36 027	MWh/yr
Capacity Factor AC	25.7	%
Energy Yield	1881	kWh/kW
Performance Ratio	0.80	-
Losses Shading	3.96	%

**Note: The shading losses are high due to the row-to-row distance that was optimised to satisfy the user requirement to maximise the installed capacity on the land. A better performing plant will have a lower installed capacity and an increase in row-to-row distance to minimise on these shading losses.*

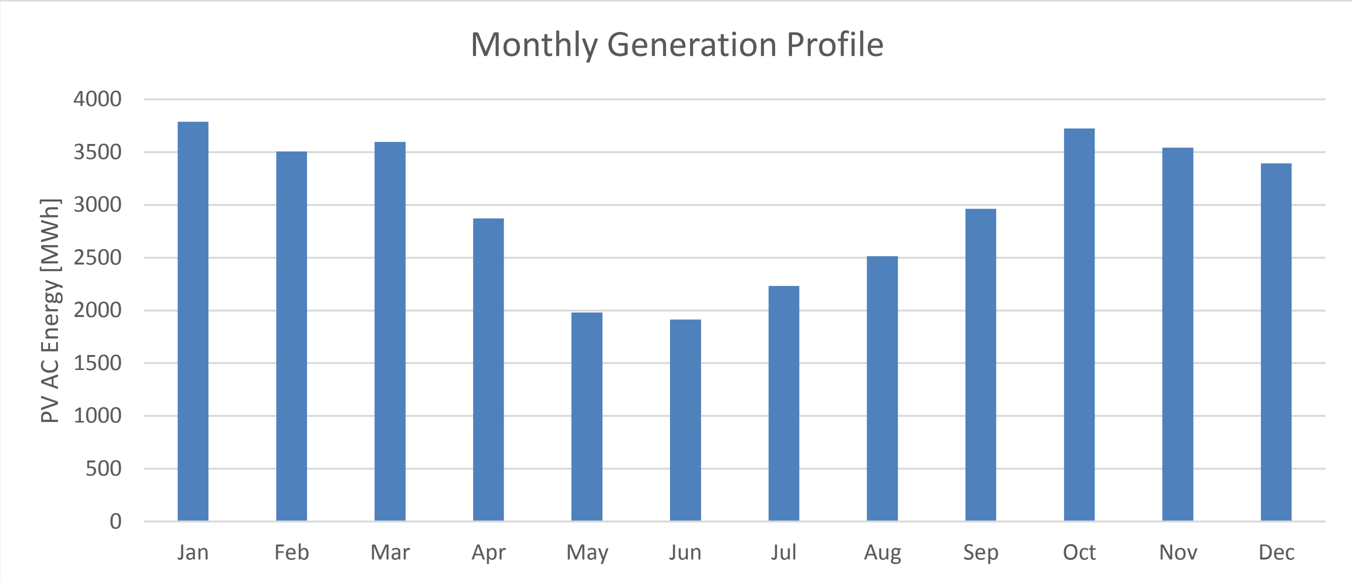


Figure 15: 16 MW monthly generation profile (year 1)

3.7.2 14 MW PV installation with single-axis tracking with backtracking

The 14 MW plant design see Table 18, and performance parameters for both tracking strategies are reported. A visual representation of the monthly energy generated by the plant for all three configurations is shown in Figure 15.

Table 18: Plant design 14 MW PV with single-axis mounting structure

Plant Design	Value	Unit
PV module rating	320	Wp
PV mounting configuration	2 rows - portrait	
Number of PV modules per string	14	
Number of parallel strings per in parallel	3276	
Number of PV modules per mounting	96	
PV module configuration (PV rows)	78	
Number of inverters	14	
PV plant DC capacity	16.76	MWdc
PV plant AC capacity	14.00	MWac
DC/AC ratio	1.2	
Tracking	Single-axis	
Tilt angle	0	degree
Axis of rotation	North-South	
Row-to-row distance	5.974	m

Road clearance between structures	2.09	m
PV plant footprint	15.56	ha

Table 19: Effect of single-axis tracking on plant performance parameters

Performance Parameters	**Value**		**Unit**
Tracking operating strategy	**Backtracking**	**No backtracking**	**-**
Installed Capacity	14	14	MWac
Annual Energy Gross Energy	35 409	32 496	MWh/yr
Annual Energy Net Energy	35 338	32 431	MWh/yr
Capacity Factor AC	28.8	26.4	%
Energy Yield	2108	1935	kWh/kW
Performance Ratio	0.84	0.69	-
Losses Shading	2.41	3.58	%

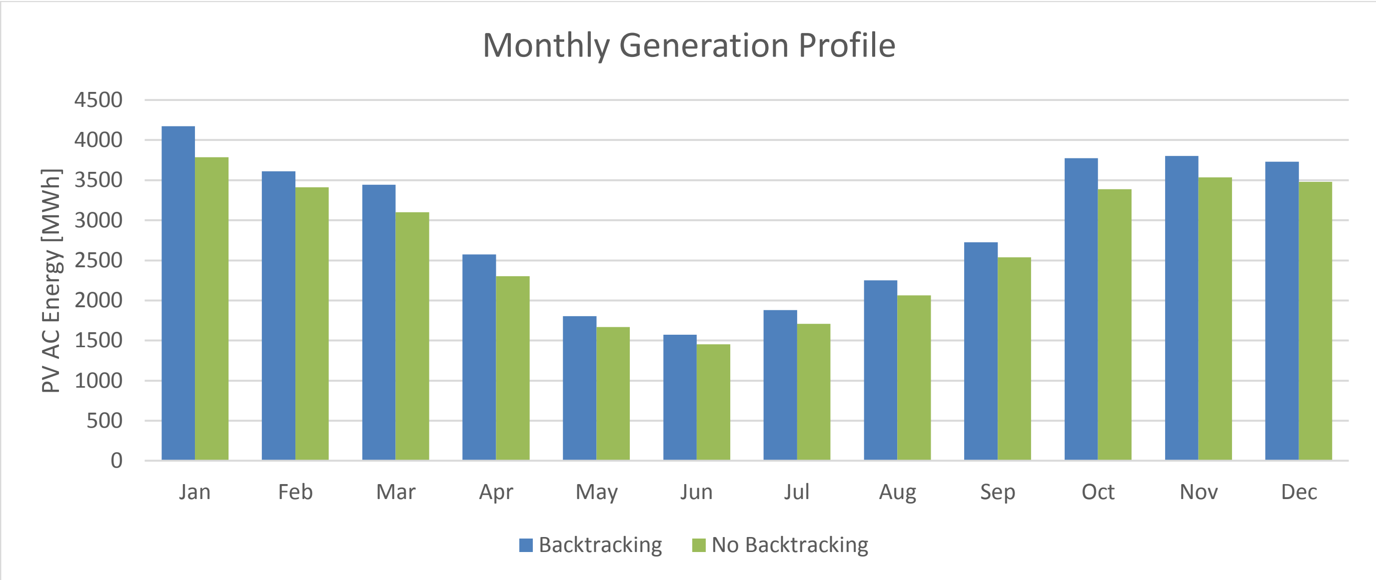


Figure 16: 14 MW monthly generation profile (year 1) comparison

3.7.3 Effect of curtailment on PV due to wind turbine generation

At the Point of Connection (PoC) there is a generating exporting limit of 105.8 MW. In the event that the generation from both PV and wind exceed this limitation, the PV generation will be curtailed. The historic plant data of Sere Wind Farm for the years 2016-2020 has been used in this sensitivity analysis. The losses due to curtailment is to inform the effect on the expected annual generation of the plant.

The 16 MW plant design (Option 3) is considered and the performance are measured for each year, see

Table 20. From the results, expected curtailment losses are in the 3-7% range. Similarly, the performance is measured on the 14 MW one-axis tracking plant, see Table 21. As expected, a higher percentage curtailment loss is expected with the tracking as wind generation is more during the afternoons.

Table 20: Effect of curtailment on annual PV generation of 16 MW fixed tilt

Plant Performance Parameters Before Curtailment						
Installed Capacity			16			MWac
Annual Energy Gross Energy			36 100			MWh/yr
Annual Energy Net Energy			36 027			MWh/yr
Capacity Factor AC			25.7			%
Energy Yield			1881			kWh/kW
Performance Ratio			0.80			-
Losses Shading			3.96			%
Plant Performance Parameters After Curtailment						
Wind generation profile	**2016**	**2017**	**2018**	**2019**	**2020**	
Installed Capacity			16			MWac
Annual Energy Gross Energy			36 100			MWh/yr
Annual Energy Net Energy	33 701	33 482	33 838	34 338	34 856	MWh/yr
Curtailment Energy	*3 267*	*2 545*	*2 189*	*1 689*	*1 171*	*MWh/yr*
Curtailment Losses	*6.46*	*7.06*	*6.08*	*4.69*	*3.25*	*%*
Capacity Factor AC	24.04	23.89	24.14	24.50	24.87	%
Losses Shading			3.96			%

Table 21: Effect of curtailment on annual PV generation on 14 MW (one-axis tracking)

Plant Performance Parameters Before Curtailment						
Installed Capacity			14			MWac
Annual Energy Gross Energy			36 100			MWh/yr
Annual Energy Net Energy			36 027			MWh/yr
Capacity Factor AC			28.8			%
Energy Yield			2108			kWh/kW
Performance Ratio			0.84			-
Losses Shading			2.41			%
Plant Performance Parameters After Curtailment						
Wind generation profile	**2016**	**2017**	**2018**	**2019**	**2020**	

Installed Capacity	14					MWac
Annual Energy Gross Energy	35 409					MWh/yr
Annual Energy Net Energy	33 103	32 765	33 188	33 632	34 276	MWh/yr
Curtailment Energy	*2 235*	*2 573*	*2 150*	*1 706*	*1 062*	*MWh/yr*
Curtailment Losses	*6.33*	*7.28*	*6.09*	*4.83*	*3.00*	*%*
Capacity Factor AC	23.62	23.38	23.68	24.00	24.46	%
Losses Shading	2.41					%

3.8 ELECTRICAL DESIGN

This section details the electrical concept for the Sere PV Plant.

3.8.1 Scope of work

Table 22: Electrical Scope of Work

Equipment	**Description**
PV Modules	PV modules as the main source of power generation.
Inverters	Inverters to convert the DC power generated by the PV modules into AC power.
MV Switchgear and protection	Switchgear and protection at MV level to enable power distribution and electrical protection up to the Point of Connection (POC) as well as Switchgear and protection to accommodate the POC.
Transformers	Step-up transformers to transform the output voltage of the inverter to the required operating voltage (33 kV), at the Point of Connection (POC)
DC and AC Cabling	DC cabling required for the DC side of the plant viz. running from the PV modules up to the input of the inverter. AC cabling required from the output of the inverter up to the Point of connection (POC).
Earthing, surge and lightning protection	Earthing system to reduce the risk (safe step and touch potential) to personnel or animals from electric shock under normal operating conditions as well as fault conditions and ensure the functionality of electrical protection equipment during electrical faults. Surge protection devices to protect the PV system against electromagnetic influences.
Metering and measurement	Tariff and Statistical metering to provide energy measurements at the POC as well as that of power quality at the same point.

Lighting and small Power	Lighting to provide illumination on the site as well as the O&M buildings. Small power such as distribution boards for power distribution of small power loads and auxiliary supply on the site as well as the O&M buildings.
Uninterruptible power supplies (UPS)	AC backup supply for equipment requiring AC supply necessary to safely shut down the plant.

3.8.1.1 Electrical Battery limits

The project makes provision for the design, plant interface design, manufacture, factory testing, supply, delivery, off-loading, move into position, installation, assembly site testing and commissioning of all new equipment forming part of the PV electrical scope of the project. Also, the design and specification limit for the electrical PV scope is the POC (inclusive of the switchgear and control) at the 33 kV Skaapvlei indoor switchgear.

3.8.1.2 Major equipment

The major equipment has been identified as:

- PV Modules
- Inverters
- 33 kV Switchgear and protection
- MV Power Cables
- Transformers

3.8.2 Design basis and criteria

The basis of design for the electrical system is the requirements stipulated in the Stakeholder Requirements Definition for Sere Solar PV Plant [1].

3.8.2.1 Stakeholder Defined Requirements

The following requirements from the users operational and maintenance plan forms the basis for the electrical systems design:

Table 23: User requirements

Criteria	Description	Electrical requirements
Functional	• The interconnection of the PV plant is at the existing Sere Wind farm Skaapvlei Substation. • The combined generation output from the existing Sere Wind Farm and the proposed PV plant must not exceed the licensed maximum power evacuation capacity of 105.8 MW.	• The POC for the Sere PV plant is on Busbar 1a and Busbar 1b of the Sere 33 kV Skaapvlei indoor substation. • The connection capacity constraint for the Wind farm and the PV plant is 105.8 MW.

Operability	• The electrical system is designed to be operable viz. be able to function with ease and as per operational requirements for as long as is expected.	• PV modules, inverters, switchgear, transformers, AC and DC cables, meters, protection devices must be operational for a minimum of 25 years. • Switchgear local and remote supervisory control. • Comply with the Renewable Grid code to insure power stability.
Availability, Reliability,	• Probability of functionality when required viz. electrical system designed to minimise the probability of failure of the plant.	• Electrical reticulation to maximise availability as far as possible. • Reliable power supply for protection devices • Main and backup supply for AC distribution board supplying the O&M building and field equipment.
Safety	• Electrical system designed in such a way that electrical hazards to human beings and animals is minimised.	• Internal arc proof switchgear, earthing systems, protection associated with switching such as overcurrent and earth faults, surge and lightning protection, fail safe operation.
Legislative	• Electrical plant design that supports grid stability.	• Compliance to Renewable Grid code requirements.

3.8.3 Existing Electrical Infrastructure

This section is discussed with reference to Appendix C: Sere Solar Farm 33 kV Station SLD and layouts.

3.8.3.1 33 kV Skaapvlei Substation

The Skaapvlei substation consists of an indoor 33 kV Skaapvlei Substation and an outdoor 132 kV Skaapvlei Substation. The POC of the Sere Wind Farm is at the 33 kV Skaapvlei indoor substation.

The switchgear that accommodates the POC of the wind farm within this substation is a metal-clad; air insulated primary switchgear equipped with vacuum breakers and consisting of 8 feeders and 2 outgoing feeders. The 7 x feeders accommodate the 7 x wind turbine generator strings, the 8th feeder is used to supply the wind farm O&M offices and workshop. The 2 outgoing feeders are respectively connected to two 80 MVA transformers that respectively allow the 33 kV Skaapvlei substation to be connected to the 132 kV Skaapvlei Substation.

The switchgear has a voltage rating of 36 kV, a main busbar current rating of 3150 A and a short time current rating of 31.5 kA/3s. It is also internal arc proof and classified AFLR that is operator safety accessibility for the front, side, lateral side and rear side of the panel.

This switchgear has been designed to accommodate 3 more feeders in its current state. These ‘spares’ are unequipped hence to accommodate the PV plant the switchgear will have to undergo panel extension as part of this project.

3.8.3.2 Sere Electrical reticulation

The Sere Wind Farm is licenced to generate a maximum of 105.8 MW. The electrical reticulation of this plant consists of 7 strings, each with a maximum of 6 or 7, 2.3 MW wind turbine generators. The power generated in each string is distributed through secondary switchgear viz. Ring Main Units. The strings are grouped accordingly and connected to 33 kV Skaapvlei substation switchgear busbar 1a and busbar 1b. There is a bus section breaker between busbar 1a and 1b which is normally closed.

The 33 kV Skaapvlei substation has 2 outgoing feeders, each connected to the 132 kV Skaapvlei Substation and limited in capacity by respective 80 MVA transformers. The 132 kV Skaapvlei substation connects the wind farm to the national grid via a 42 km long, 132 kV Juno – Skaapvlei line. This is the only line and there is no redundancy. The maximum capacity on this line is limited to 176 MW.

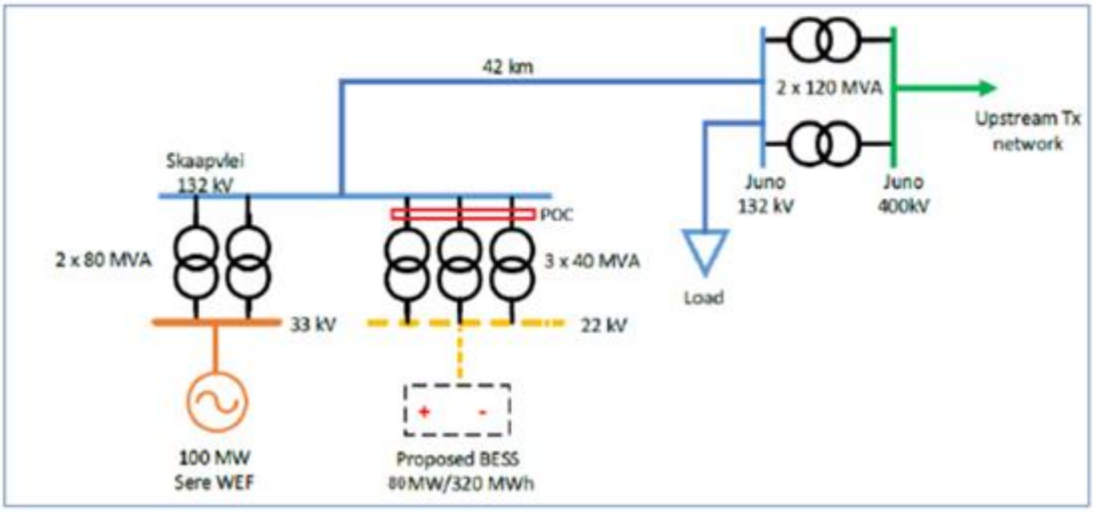


Figure 17: Sere Wind Farm and BESS in relation to the Juno Substation (Source: DX Planning)

The extra capacity on this line will be utilised by the Eskom BESS programme which is at an advanced stage of procurement. The intent is to install a BESS with a capacity of 80 MW / 320 MWh at the 132 kV Skaapvlei outdoor substation.

The exiting feeder allocation on the 33 kV Skaapvlei indoor switchgear is as shown in Table 24

Table 24: 22kV Skaapvlei Wind Feeder Allocation

33 kV busbar 1a connected loads	Capacity (MVA)	33 kV busbar 1b connected loads	Capacity (MVA)
String 1-FDR 3	16.1	String 5-FDR 11	13.8
String 2-FDR 4	13.8	String 6- FDR 12	16.1
String 3-FDR 6	16.1	String 7-FDR 14	13.8
String 4-FDR 7	16.1		
Total Capacity	62.1		43.7

According to this feeder allocation, the maximum power that can be generated by the wind turbines and fed into the 33 kV Skaapvlei busbar 1a, is 62.1 MVA; the maximum power that can be generated and fed into the 33 kV Skaapvlei busbar 1b, is 43.7 MVA.

3.8.4 PV Plant Electrical Reticulation Philosophy

The reticulation philosophy for the PV plant is driven by the constraint to limit the combined generation output from the existing Sere Wind Farm and the proposed PV plant to the licensed maximum power evacuation capacity of 105.8 MW. Based on Table 3, the maximum PV capacity that can be accommodated at the 33kV Skaapvlei busbar 1a is 17.9 MVA whilst a maximum of 36.3 MVA can be accommodated at busbar 1b. The proposed electrical reticulation for the PV plant must comply with this philosophy to accommodate the capacity constraints. For this reason, 2 points of connection, 1 on busbar 1a and another on busbar 1b is required to accommodate the PV plant.

3.8.5 Electrical Reticulation Concept

3.8.5.1 DC system

The DC system mainly comprises of PV modules, DC cabling, combiner boxes, protective devices, and disconnector switches. PV modules are first connected in series to make a string. A group of strings (arrays) is then connected to the inverter through combiner boxes. The PV design (discussed in an earlier section utilizes polycrystalline modules with a central inverter topology configuration.

3.8.5.2 AC System

The AC system comprises mainly of step-up, two winding transformers, collector busbars (switchgear and protection) and AC cabling. The AC system facilitates power collection and distribution within the internal PV plant up to the POC.

3.8.5.2.1 Collection grid options

There are two internal PV plant electrical AC reticulation topologies that can be considered for this project viz. ring topology and star topology

a) Ring Topology MV connected PV

In a ring topology a closed ring of PV generators is created where either side of the ring is connected to a central collector system at MV level as shown in Figure 18.

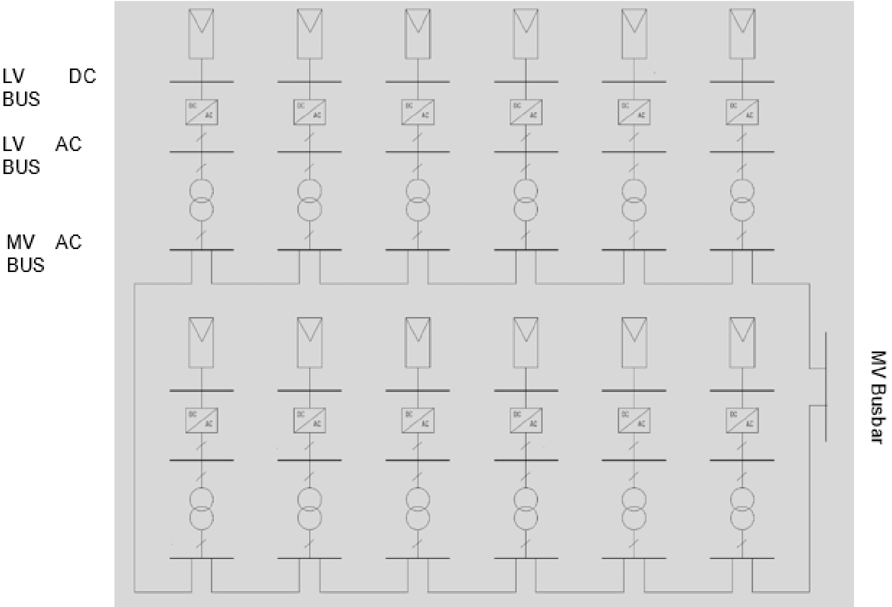


Figure 18: Ring Topology, MV connected Network

b) Star topology MV connected PV

In this option, each embedded PV generator viz. one generator consisting of modules, inverters, switchgear and transformer is individually connected to a central collector system at MV level as shown in Figure 19.

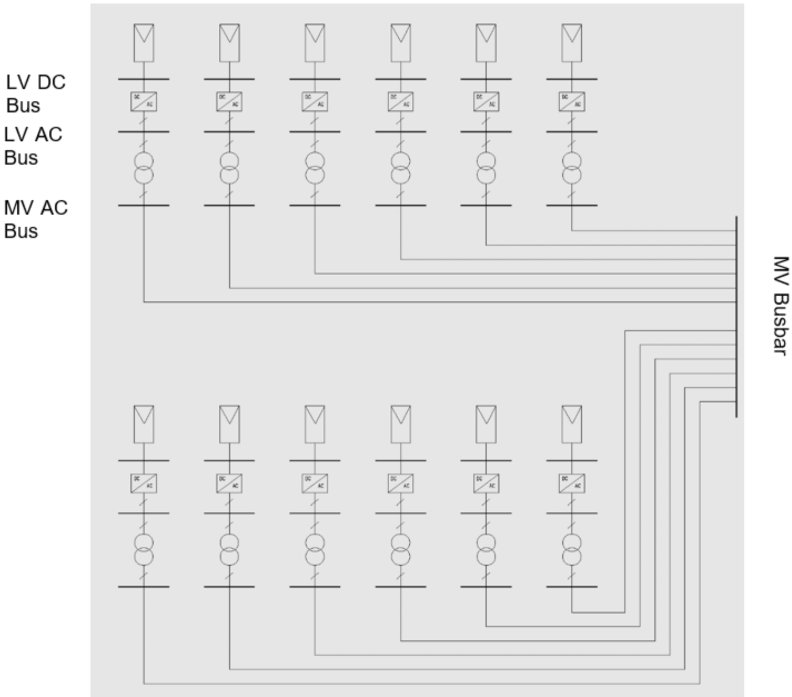


Figure 19: Star Topology, MV connected Network

3.8.5.2.2 Comparison of options

Table 25: Comparison of Electrical Reticulation Topology Options

Topology	Advantages	Disadvantages
Ring topology	• The ring can be configured to send power in two directions from the generation source. The primary direction is established for normal operation. The alternate direction is established if one of the generators or cable is faulty. The topology is single fault tolerant hence offers a good reliability for the plant, • Less costly option	• Not as reliable as a star topology, • May violate the capacity constraint to maintain the maximum power evacuated at 105.8 MW under faulty conditions.
Star topology	• Most reliable because the failure of a PV generator or cable does not affect the other generators.	• Uses the most cable and thus is more costly to install as compared to the ring topology,

3.8.5.2.3 Discussion and Recommendation

The preferred solution will be to implement a ring topology as in this instance; the PV generators are looped, thus resulting in lower cable cost when compared to a star topology. Also, the ring is configured to send power in two directions from the source. In the case where one of the generators or cable is faulty, the power generated by the running PV generators in the loop goes in the alternate direction allowing power to still be fed into the substation. It is however possible in this configuration to violate the capacity constraints in instances where the wind turbines are generating at maximum with the likelihood being higher on busbar 1a, as that's where the least available capacity is. The proposed optimum solution, hence, is to maintain the ring formation however to limit connection at busbar 1a at 17 MVA and 36 MVA on busbar 1b. This can be done by keeping a normally open disconnector in the loop which can be closed as and when necessitated by operational requirements.

3.8.6 Technology Assessment

This section discusses the technology options available for the major equipment.

3.8.6.1 PV Generator Power Distribution Switchgear

The market survey showed that there is primary distribution Air Insulated Switchgear (AIS), Gas Insulated Switchgear (GIS) and secondary distribution Gas Insulated Ring Main Units (RMU) available as possible solutions for the collection and distribution of AC power at the PV plant. In addition to these switchgear technologies, another technology that is widely used in solar PV applications for power collection is an integrated MV inverter cabin which provides power conversion, voltage transformation, power collection and protection for a solar PV plant. By virtue of the proposed reticulation topology, the most applicable switchgear technology type in this case is the RMU switchgear.

A Ring Main Unit, (RMU), is a medium voltage metal-enclosed secondary switchgear assembly that comprises a combination of switch-disconnectors, switch-fuse combinations, or circuit-breaker functions. These functions incorporate integral cable earthing switches and have facilities for cable testing. This type of switchgear typically has low fault and current ratings and simple protection and control capabilities and has fewer mechanical operations compared to primary switchgear.

The inverter/MV cabin is not switchgear however it is a fully integrated technology available in the market for solar PV applications. The typical solution is an MV inverter cabin or shelter which favours a central inverter configuration. The cabin is a compact modular type-tested assembly which includes an inverter, LV distribution board, step-up transformer, MV switchgear and protection and an optional LV/LV auxiliary supply transformer. It operates between the DC field and AC MV grid connection point and carries out the DC/AC conversion and AC voltage elevation to the grid voltage level. The cabin is also equipped with protection devices that ensure the protection of maintenance personnel and against electrical defaults such as short-circuit and lightning.

3.8.6.1.1 Discussion and Recommendation

AIS and GIS primary switchgear is the least suited for this application. The MV inverter cabin technology is the optimal solution for this application. It offers a more compact integrated solution that enables power conversion, transformation, and collection. Also, keeping the major equipment in an enclosed cabin mitigates against the risk of corrosion typically present in coastal areas. Although the mechanical operations of the RMU are less compared to primary switchgear, it is acceptable in this case because there will be minimal switching in this application.

3.8.6.2 Transformers

Technically both liquid immersed and non-liquid immersed transformers are suitable in for this project however, to minimise risks of fire non-liquid immersed transformer is proposed. Also, it is most suitable for the inverter cabin solution proposed.

3.8.6.3 Cabling

Power from the strings of PV generators will be evacuated through underground power cables. This is a suitable solution for this project as the point of termination i.e. 33 kV busbar is localised i.e. approximately less than 1.5 km away. Typical competitive technology types for MV power cables are the paper insulated lead covered cable (PILC) and Cross-linked polyethylene cable (XLPE). PILC cable is the oldest cable technology used in entire voltage range starting from 1.1 kV ac to 750 kV ac. PILC cable is being gradually replaced by less hygroscopic polymeric insulated cable, XLPE. XLPE cable has distinct advantages, lighter weight, better electrical and thermal properties, less maintenance, and easier terminating procedure. XLPE is most suitable for this application where the service life of the plant is limited to 30 years and the soil conditions have limited moisture content. Currently XLPE cable is widely available and being extensively used in most installations. This cable technology type is recommended for AC MV cables.

3.8.7 Concept design proposal

3.8.7.1 DC System Design

The overall PV field is divided into sub-fields referred to as ‘PV blocks’. As seen in Appendix C: Sere Solar Farm PV Block DC SLD, each PV block is equipped with PV Module arrays, combiner boxes, fuse boxes, DC cabling and a central inverter as shown in Figure 20

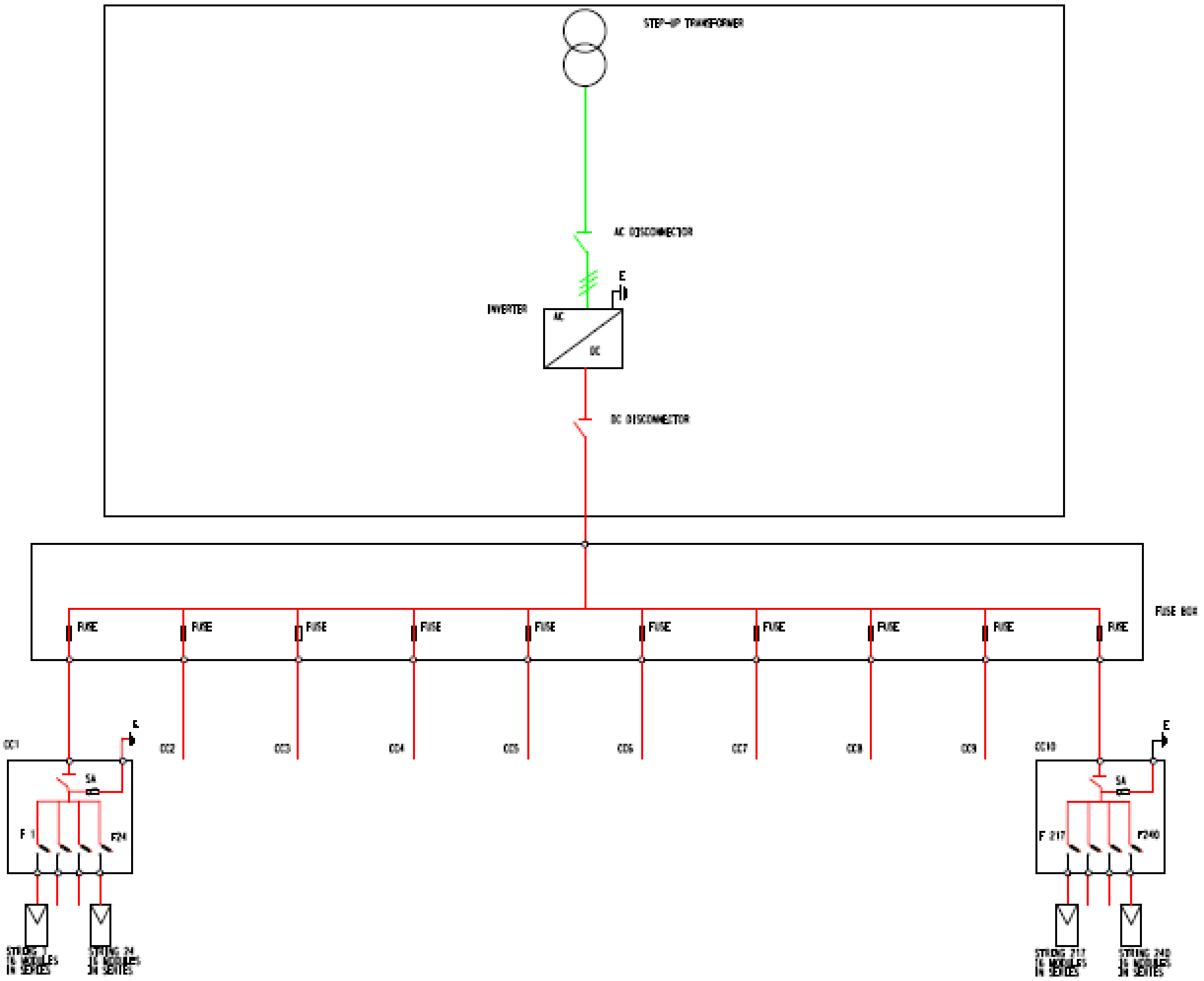


Figure 20: Combiner Box String Configuration for Single PV Block

3.8.7.2 Combiner Box

The combiner box collects individual strings to form an array by terminating the individual string connections at the combiner box terminals. It houses the fuses for overcurrent protection for each individual string, on-load disconnector switch for array isolation and surge arrestors for over voltage protection. The combiner box is located between the solar field and the inverter. The fuse box can be a separate box or integrated to the inverter depending on the inverter type.

3.8.7.3 DC cabling

DC cables refer to the electrical wiring that interconnects the PV modules and the inverter. This is the wiring indicated in red in Figure 21 and on the indicative DC PV block SLD in Appendix C: Sere Solar Farm PV Block DC SLD .The minimum cable sizes shall be based on a current rating calculation.

3.8.7.4 Inverter

The inverter will have a DC disconnect switch and an AC disconnect switch on each side for isolation and maintenance purposes. The inverter will have the capability of detecting islanded operation as per the grid code referenced in this document. The inverter considered in this proposal is a 1 MW ac central inverter.

3.8.7.5 AC system Design

The proposed design considers an AC electrical reticulation through MV inverter cabins. Each PV block contains 1 × inverter, 1 × transformer and 3.3 kV RMU switchgear as shown in Appendix C: Sere Solar Farm 33 kV AC SLD. The cabin houses inverter(s), transformer(s) and MV switchgear. Each inverter is connected to the transformer via an AC disconnect switch for isolation and maintenance purposes. The RMU is used to connect or loop to other adjacent inverter cabins and for inverter cabin isolation and protection. Each RMU accommodates one PV block. Figure 21 shows the arrangement for one such cabin. LV auxiliary supply for each inverter cabin is provided by LV/LV transformer inside the cabin.

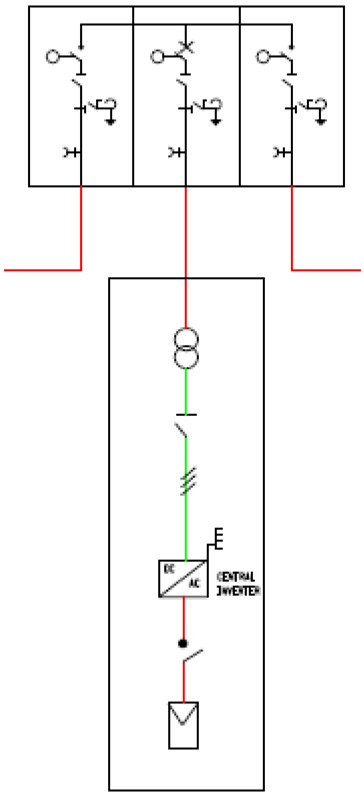


Figure 21: Arrangement in an MV inverter Cabin

3.8.7.6 Step-Up transformers

The step-up transformers in this design have two windings, one for low voltage (LV) and other for Medium voltage (MV).The transformers will step up the LV voltage at the output of the inverter to the required operating level of 33 kV at the POC.

3.8.7.7 Ring main unit (RMU)

The RMU comprises a combination of switch-disconnectors and circuit-breaker functions. As there is a requirement for remote control, the RMU is fitted with a remote terminal unit (RTU). Each MV cabin accommodates one PV block in the indicative design. The RMU configuration for each MV cabin is R-B-R viz.:

- ‘R’ for a switch disconnector

- 'B' for a circuit-breaker

The first and third panel consist of switch disconnectors; three positions switch each with their own disconnector and cable earthing switch. The second panel consist of a circuit breaker for transformer protection.

A suitable protection relay with the capability to perform protection (overcurrent, earth fault, under-and – over voltage protection),fault recording and calculation functions with a mimic that indicates the breaker status, remote control and monitoring of the breakers is required. The relay and all associated equipment should be specified for use with AC power supplies. The protection relay is installed for each circuit breaker forming part of the RMU.

Adequate mechanical interlock system designed (according to Eskom standard 240-56030406) for the circuit breakers, disconnect switches and the earth switches to prevent mal-operation and to ensure operator safety is required. The design of the interlock system must prevent the operator from physically overriding the interlock controls.

The main functionality and features of the RMU is as follows:

- MV CB for transformer protection
- Cable disconnect switches for isolation or maintenance
- Earth Switches
- Interlocking for the CBs, disconnect switch and the earth switch
- CBs disconnect switch and earth switch provision to be locked in the ON/OFF position.
- CBs disconnect switches and earth switches capable of being operated local and on remote.
- Metering and Measurement
- Internal arc classified
- Free standing suitable for use in the cabin

3.8.7.8 Point of Connection

The identified POC is the 33kV indoor switchgear located in the Skaapvlei substation. This substation is an Eskom distribution network component and is thus operated by Eskom Distribution. The Skaapvlei substation is the collector substation for the 100MW Sere Wind Farm. This Skaapvlei substation connects to Juno Main Transmission Substation via a 132kV line.The new breaker panels and associated equipment required to accommodate the POCs is to be extended to the existing 33kV switchgear. The existing gear consists of 12 single busbar panels. Floor frames have been installed to the left and right of the existing switchgear for future panel extensions. The extension panels will comply technically with the existing breaker panels. The new panel and breaker shall comply with all internal arc, mechanical service, voltage, and current specifications of the existing switchboard as well as comply with any additional requirements for the PV plant installation such as the metering and measurement requirements.

The breaker panel shall comply with 240-56065131 and manufactured in accordance with SANS 62271-200. The on-board protection scheme shall comply with all the protection functionalities currently provided by the protection schemes installed on the existing feeders which include the following: O/C & E/F protection, Arc flash Busbar Protection and Breaker Fail protection. Arc flash and breaker fail functions to be integrated into the IEC61850 system by using Goose messaging. Furthermore, the protection relay shall have event recording facility and provide DNP3 protocol via RS485 to the existing SCADA system. The protection relay shall also be capable to interface with the existing Remote Engineering Access IEC61850 protocol installed at the substation.

The 33kV Breaker Panels will be respectively connected to the Solar PV plant via two respective XLPE 33kV cables. All new 33kV cables will comply with 240-56063792 - Specification for Medium Voltage

XLPE And Impregnated Paper Insulated Cables Standard. All new cable accessories will comply with 240 – 56030619 – Accessories for Medium-Voltage Power Cables for Systems with Nominal Voltages of 11kV to 33kV Standard.

3.8.7.8.1 Metering and Measurement at PoC

Tariff Metering

Full four quadrant tariff metering (Class 0.2) Main and Check energy meters will be installed at each 33 kV PV POC feeder at the 33 kV Skaapvlei Substation as per the indicative design in Appendix C. The meters shall be capable of providing the following at minimum:

- Tariff metering,
- Bi-directional energy measurements
- Power quality analysis with harmonic measurement capability
- Demand and power factor control
- Load curtailment
- Equipment monitoring and control
- Energy pulsing and totalisation
- Instrument transformer correction

The meters procured must be listed in the Eskom standard 240-56227589; List of approved electronic devices to be used on Eskom Power Stations.

The tariff metering installation shall be in accordance with 240-56364444, Standard minimum requirements for the metering of electrical energy and demand. This includes but is not limited to the requirements around the accuracy class of the meters, CTs and VTs.

The metering equipment shall be installed in a standard metering panel according to 240-65292589, Standard for Switching Station Meter Panels: HV/MV Indoor. The panels shall include meter modules, modem modules or VT selection modules, where applicable.

3.8.7.9 PV Plant Auxiliary Supplies

3.8.7.9.1 Field equipment

The LV auxiliary supply required for the PV plant field equipment is provided through a PV field auxiliary supply DB which is supplied from an LV/LV transformer which can be located inside the MV cabin. This transformer taps off the output of the inverter and steps down to the applicable LV required by the Auxiliary loads. These loads can be localised loads such HVAC systems, UPSs, lighting, etc. The field auxiliary DB can be located outside the MV cabin and hence suitable for outdoor applications. It should also be easily accessible. Backup supplies for the auxiliaries are provided through a UPS system which is fed from the LV/LV transformer. The UPS and associated equipment are located in the MV cabin.

3.8.7.9.2 O&M building

Auxiliary power to the Sere wind farm administration building and workshop areas is supplied through a 1 MVA transformer owned and operated by Eskom Distribution. The same transformer is proposed to be used to supply auxiliary power to the PV O&M building. Auxiliary loads include HVAC, lighting, socket outlets, CMS and related equipment, security systems (perimeter lighting, cameras, gate motors, etc.), UPSs, telephones, fire detection, etc.

These loads will be supplied through an auxiliary DB (distribution board). The sizing of the board is to be based on the short-circuit study and PV plant auxiliaries load requirement. Backup supplies for the auxiliaries are provided through a UPS system which can be fed from the existing Sere Wind Farm DB.

3.8.7.10 Backup Supplies

Uninterruptible Power Supplies (UPS') will be used to provide ac backup supply to electrical equipment located in the field and power the SCADA system in the O&M building.

3.8.7.10.1 PV Plant Security Lighting

Security lighting shall provide sufficient illumination to secure zones and external areas of the PV plant. Illumination shall be designed according to the security design.

3.8.7.11 Earthing and lightning protection

An earthing system shall be provided in the solar PV plant and shall be designed and installed in accordance with Eskom and all other applicable standards such as IEEE80. The fault levels at the solar PV plant will be used as input to the design. The design shall reduce the risk (safe step and touch potential) to personnel or animals from electric shock under normal operating conditions as well as fault conditions. It also ensures the functionality of electrical protection equipment during electrical faults.

Earthing and lightning protection installation shall meet the applicable standards including, but not limited to Eskom standard 240-56356396, SANS 10142-1, SANS 62305 and IEC 60364-7-712. Earthing and lightning protection is achieved by means of a well-structured and integrated earthing system. It starts with earthmats, electrodes, structures etc., all connected to form a network. The electrical equipment is then connected to the earthing network. The current solution for grounding and lightning protection consists of three elements: Earthing; Equipotential bonding; and Surge Protective Devices all of which shall be assessed and designed by the EPC.

Single core MV cables shall be single point earthed as per Eskom standard 240-56227443 and any other applicable standards. All exposed conductive parts of the PV system (e.g. module frames, mounting frames, cable trays, weather station, etc.) will be earthed via an equipotential bonding structure. The aim of bonding is to bring all the bonded parts to the same electrical potential to avoid dangerous differences in voltages. The bonding conductors shall be parallel to and in close contact as possible with D.C. cables and A.C. cables and accessories (source: IEC 60364-7-712). Where the bonding conductors are likely to carry lightning current, the cross-sectional area of the conductor shall be sufficient sized.

3.8.7.12 Surge Protective Devices

Surge protection devices shall be installed to protect the PV system against voltage surges. Surge protection devices shall be installed at the combiner boxes, inverters' DC inputs and AC sides, interconnection lines and PV plant auxiliary distribution boards.

3.8.8 GRID CODE REQUIREMENTS

The PV system will be designed to meet the latest requirements of the Grid Connection Code for Renewable Power Plants (RPPs) Connected to the Electricity Transmission system (TS) or the Distribution System (DS) in South Africa, where compliance to this code will be assessed at the POC. A PV plant of maximum 20 MVA falls under Category B of the Grid code definition, that is, a plant sized between 1 MVA and 20 MVA connected at MV level, however, to enable the grid code compliance of the Sere wind and PV plant as a hybrid, the solar PV plant is required to match the category of the Wind plant which is category C

Table 26 summarizes the major Grid Connection technical requirements that apply for this plant to ensure the safe operation of the plant in conjunction with the grid. The plant is required to disconnect from the grid automatically and safely in the event of an abnormal condition.

Table 26: Minimum Plant Technical Grid Code Requirements

Grid Code Requirement	Description
Voltage Range	Operating continuously within the POC voltage range of 0.9 pu and 1.08 pu.
Frequency Range	Allowed frequency is within the range of 49.0 Hz and 51.0 Hz to the grid. The plant shall disconnect when its frequency is higher than 51.5 Hz for longer than 4 seconds or less than 47.0 Hz for longer than 200 ms. The plant is to synchronise with the grid before a connection is established according to category C synchronising conditions stipulated in the Grid Code.
Voltage Ride Through	The plant shall be designed to withstand voltage drops to zero, measured at the POC, for a minimum period of 0.15 seconds without disconnecting. It shall also be designed to withstand Voltage peaks up to 120% of the nominal voltage measured at the POC, for a minimum period of 2 seconds without disconnecting. The plant shall comply with the voltage ride through capability for a category C utilising non-synchronous machines.
Power Quality	Plant power quality is measured at the POC. Voltage jumps, phase jumps and harmonics at the POC are required to be maintained within the desired range. As a result, the plant must be able to withstand sudden phase jumps of up to 40° at the POC without disconnecting or reducing its output. After conditions at the POC have reverted to normal, the maximum allowed settling period to resume normal operation is 5 seconds. Power quality parameters to be reported on flicker, harmonics, and unbalanced voltages.
Power Frequency Response	In case of frequency deviations, the plant shall be designed to be capable to provide power-frequency response to stabilise the grid frequency. This is done by either supplying additional generation or reducing it. During high frequency >50.5 Hz, operating conditions, the PV shall be able to provide mandatory active power reduction requirement to stabilise the frequency. During high frequency > 51.5 Hz for longer than 4 seconds the PV shall be tripped. Additional power frequency response requirements specific to category stipulated in the grid code, are also applicable for this plant.
Reactive Power Capabilities	When operating between 5% and 100% of rated power (MW) the plant of category B shall have the capability of varying reactive power (Mvar) support at the POC within the reactive power capability ranges as illustrated by the Reactive power requirements for RPPs of category C at the POC figure in the Grid Code.
Protection and fault levels	The RPP generator shall ensure that the plant is dimensioned and equipped with the necessary protection functions so that the plant is

	protected against damage due to faults and incidents in the Transmission and Distribution system as per the grid code. The RPP of category shall be equipped with effective detection of islanded operation in all system configurations and capability to shut down generation of power in such condition within 2 seconds. Islanded operation with part of the TS or DS is not permitted unless specifically agreed with the Network Service Provider.

The Control Function Requirements to aid in the overall control and monitoring of the plant are summarised below:

Table 27: Plant Required Control Functions

Control Function	Description
Voltage Control	The plant shall have a voltage control function to control the voltage at the POC.
Power factor Control	The plant shall have a power factor control function to control the reactive power proportionally to the active power at the POC
Reactive Power	The plant shall have a reactive power control function to control the reactive power supply and absorption at the POC independently of the active power and the voltage.

Note: All function requirements shall be as per the Grid Code

3.9 CONTROL AND INSTRUMENTATION DESIGN

3.9.1 Control and Monitoring system (CMS) Network Design

3.9.1.1 Network Description and Network Operation

The on-site Control and monitoring system (CMS), otherwise known as the Supervisory Control and Data Acquisition (SCADA) system, will be required on-site. The on-site CMS will be responsible for data acquisition and monitoring of instruments and equipment, that include,

- PV Inverter systems,
- PV meteorological systems (Weather stations),
- PV string combiner boxes,
- Electrical Medium voltage (MV) switchgear,
- Electrical transformers,
- Electrical Protection relays,
- Electrical Energy measurement and metering,
- CMS Uninterruptable power supplies (UPS),
- CMS Internal environmental sensors of equipment cabinets,
- BoP potable water and sewage tank levels,
- BoP Fire detection system (FDS),
- BoP Heating, ventilation, and air-conditioning (HVAC) system

The plant will include a control room for two (2) plant operators. The Sere Wind Farm control room will be shared for this purpose. Under normal operating condition, the plant is expected to operate automatically with minimal operator intervention.

The on-site CMS will include redundant plant information servers to store all plant production data for the lifespan of the plant. All redundant equipment shall be alarmed if a failure occurs to return the functional redundant system to service as soon as possible. The on-site CMS will include a web-server that securely communicates real time and historical plant data to web-clients. The web-clients are remote users with authorised access for monitoring the plant in near real time via a web browser. A standardised set of display pages will present data to the local operator and remote users.

The CMS will automatically generate and send a short message service (SMS) notification to Eskom maintenance staff in the event a breaker at the POC or a central inverter is automatically disconnected from the power grid under a fault condition experienced during normal operation. The SMS will notify the user of the fault condition resulting in automatic disconnection.

A daily, weekly, and monthly report of the plant production will be generated automatically and sent via email notification to authorised users.

3.9.1.2 Network Architecture

The network will be single fault tolerant and will form the backbone CMS network to enable data communication between the field equipment and CMS servers. Any fault in a single segment of the network should not cause data communication failure between the control room and the plant. The core network will allow for full duplex communication.

The PV plant will contain a CMS network panel that connects the various sub-systems of the plant:

- Central inverters,
- Auxiliary power (LV) and generator transformers (MV),
- Switchgear MCCBs and status indication relays,
- String combiner boxes,
- Weather stations,
- UPS and
- Fire panels.

The CMS network panel will be installed inside the inverter cabin. Active cooling of the equipment is required.

The substation will include a CMS network panel that connects to the CMS network. The panel will interface to:

- Switchgear breakers and status indication relays (including IEDs),
- protection systems,
- UPS,
- Fire panel (In O&M room)
- HVAC panel (in O&M room).

There will be one pair (2) of redundantly configured CMS servers and one pair (2) of redundantly configured network switches that will be installed in the Sere Wind Farm O&M building server room to store the plant data, process the data and present information to the operator via the human machine interface (HMI) of the operator systems. It is preferred that a Master-slave redundant configuration is employed for the network switched and servers located at the server room. Each CMS server will include a plant information server which will store all plant production data for the lifespan of the plant. The plant is required to have two (2) operators, therefore, two (2) thin client PCs will be required for the operators in the control room. A single CMS software application will be installed onto the CMS servers for control and monitoring of all plant equipment.

At an operational level, redundancy will be employed such that any failure of a server, or a thin client, or network switch should not result in loss of operations and monitoring of the plant.

A common network switch will be installed in the network cabinet of the server room for interfacing to systems such as:

- GPS based time synchronisation system,
- Control building HVAC system,
- Server room UPS monitoring,
- HVAC panel (at O&M building),
- Network printer,

The firewall, webserver and VPN gateway are required for highly secured and stable connectivity of the PV plant to the internet. The Eskom Cyber Security, DMZ, IT/OT interface standards need to be complied with.

3.9.1.3 CMS Servers

There will be one pair (2) of redundantly configured CMS servers. The servers are required to operate as a primary-standby configuration. The standby server will continue full operation of the CMS if the primary server fails to operate normally. A high speed (watchdog) interface will interconnect both servers to establish a dual redundant configuration. Each server machine of the redundant pair will include the following hardware:

- Redundant central processing units (CPU),
- Redundant array of independent disks (RAID) configuration,
- Redundant power supplies with dual power input ports,
- 19” (inch.) rack-mountable type enclosure,
- on-board memory to continuously process and store all real time plant data for the lifespan of the plant,
- Removal media such as a digital versatile disk (DVD) writer and front accessible universal serial bus (USB) ports.

The dual redundant CMS servers will accomplish multiple functions that include:

- hosting the latest Windows operating system,
- hosting a single CMS application software for operating and monitoring of all equipment.
- hosting anti-virus software,
- store all engineering logic and CMS network configuration settings,
- processing of plant data via the redundant information servers and storage of data onto the CPU database,
- communicating to the thin clients for plant operation and network configuration,
- network configuration, logic development, mimic development, antivirus, and software updates,
- automatic copying of data from the CPU’s built-in historian onto the removable media at pre-configured intervals, and
- saving of information, backing up of data onto removable media, closing all running applications and shutting down the CPU in an automatic sequence after detecting the loss of the input power to the UPS system.

The operating system and application software versions will be confirmed during tender clarifications.

3.9.1.4 Operator System Thin Clients

There will be two (2) thin client machines for the HMI between the plant operator and the CMS servers. The thin clients will be configured such that each thin client can be used to operate and monitor the entire plant with full functionality. Both thin client machines will be configured to run simultaneously, i.e. 100% operational redundancy.

Option 1: Thin clients will be installed at the operators' desk in the control room.

Each thin client will be a tower type and will be securely installed on the plant Operator's desk. Operating temperature within the control room will be uncontrolled since operators are likely to switch off the air-conditioner during seasonal periods. Thin clients will be exposed to warmer temperatures if heat mode is switched on HVAC system in the control room. Care must be taken to allow for circulation of heat generated by the thin clients. Improper air circulation will expose the thin clients to higher operating temperatures due to thermal runaway. This will deteriorate the lifespan of the thin clients and could cause repetitive failures during operation.

Option 2: Thin clients will be installed at the server room.

The thin clients will either be tower type or 19" rack type installed in the network cabinet. KVM (keyboard, video, and mouse) extenders will be required to extend the use of the peripherals between the thin clients at the server room and the HMI peripherals at the control room. The advantage of using KVM extenders is realised through the benefit of installing the thin clients inside a controlled environment. The disadvantage of this method is the additional cost for KVM extenders.

Industrial type KVM (keyboard, video, and mouse) extenders are used to extend data communication between the thin clients located at the server room and the peripherals and monitors located at the control room. Depending on the requirement, each KVM extender is equipped with multiple ports (I.e. SUB-D, PS2, HDMI, USB, Ethernet, DisplayPort). The interface between each KVM is an Ethernet cable.

The KVM extenders should not degrade the video quality, as displayed on the operating screens, nor should it introduce any operating delay. All KVM extenders will be securely installed at the operators' desk to prevent physical interference. It is recommended the KVM extenders be rated for industrial use.

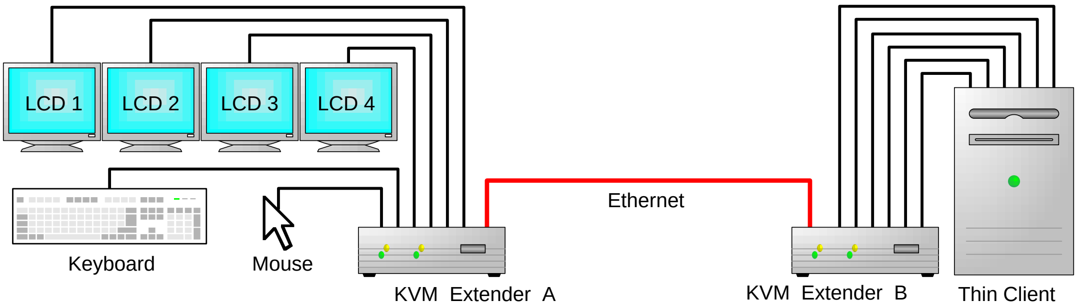


Figure 22: Typical implementation of KVM extenders

Recommendation:

Option 2 is recommended to maintain a fixed operating temperature of the thin client machines. This ensures that the lifespan of the equipment will not deteriorate and that the control room temperature can be adjustable to suit the plant operator's needs. The server room is situated next to the control room.

3.9.1.5 Network Switches

Industrial Ethernet network switches will be installed to communicate between multiple network nodes. The switch will include as a minimum:

- managed type with management and configuration via the CMS server,
- monitoring of the port connections, communication link status, bandwidth, and device health status indicating alarms and faults to the server and remote users,

- compatibility with Simple network management protocol version 3 (SNMP v3) and Internet protocol version 6 (IPv6),
- power supply from dual redundant power sources (230 Vac or 24 Vdc),
- dual power input ports
- mounted on a Deutsche Industrie Norm (DIN) rail in CMS network panels, or, mounted on a 19" network cabinet for redundant master switches located in the server room,
- ingress protection (IP) 20 rating as minimum,
- 20% spare network ports (rounded up),
- wide operating temperature range,
- optical fibre and Ethernet ports,
- auto negotiation, and
- auto crossover (MDIX)

3.9.1.6 Network Printer

There will be one A3 colour printer installed in the PV plant control room and connected to the CMS network.

3.9.1.7 Network Time Synchronisation

Over a period of time, the internal clock of each device will drift from the internal reference point. A time synchronisation system will be installed to synchronise the time of the system clock of each device connected to the CMS network to a common time source. A GPS type time synchronisation system uses the geographical position of the plant and orbital satellites to continuously update the time source with reference to the Universal time clock (UTC). Common clock synchronisation assures consistent stamping of data onto the CPU historian database which simplifies data analysis and troubleshooting during an investigation. The time synchronisation system will include a Global positioning system (GPS) antenna and a time server. The time synchronisation system will implement the network time protocol (NTP) via an Ethernet connection to the CMS network switches. Time stamping with an accuracy of ±10 milliseconds (UTC+2) is required.

3.9.1.8 CMS Network Panels

The CMS network panel will be installed inside each inverter cabin and the switchgear rooms. The following equipment will be installed inside each CMS network panel:

- a managed type optical fibre switch with multiple ports.
- network protocol or medium convertors (E.g.: RS485 to Ethernet),
- digital or analogue input or output (IO-Ethernet modules) to measure signals from the ambient air temperature and relative humidity sensors inside each CMS network panel,
- an optional programmable logic controller (PLC) with on-board IO cards and protocol convertors,
- splice trays for fibre optic cables (located in a separate compartment of the network panel),
- cable channels, terminal strips, and
- 24 Vdc DIN rail mount power supplies.

All electronic equipment installed inside CMS network panels will be suitable for continuous operations in an uncontrolled environment subjected to wide temperature ranges.

The panel will be designed such that the following equipment is physically segregated from each other within the panel:

- Electronic network equipment (switches, protocol or media convertors, IO cards, PLCs, internal temperature sensors, etc.),

- power supply and associated equipment, (MCBs, SPDs, etc.) and
- Splice trays and patch panels for optical fibre cabling.

3.9.1.9 Server Room Network Cabinets

The CMS servers, thin clients, redundant network switches and UPSs will be installed in 19” rack type network cabinets. It is preferred that patch panels be mounted in separate network cabinets from the servers. As far as possible, all connectors on rack mounted components must be rear facing in the cabinet for easier cable management. Network cabling will be top entry while power cabling will be bottom entry. The server room network cabinets will have the following characteristics:

- Top and bottom panels with holes for cable entry,
- Grommets will be installed where panels are cut for communication and power cable entry,
- Internal cable channels or traces to neatly route cables inside the cabinet,
- Removable blanking panels on all unused slots or sections,
- Sufficient depth (> 200mm free space) to allow air circulation around cables in the rear,
- Perforated front and rear door and side panels to allow circulation of air,
- Flexible brushes to be used to prevent air leakage via cable entries or cut-out,
- Include 19” racks and DIN rails to mount equipment,
- Removable perforated front and rear door panels,
- Doors with manual locking mechanism and automatic open/close detection,
- Internal lights for illumination,
- IP 20 rating,
- 20% uninstalled space on the racks and DIN slots to install spare equipment, and
- internal air temperature and relative humidity sensors monitored on the network cabinet (local) and the CMS (operator HMI). Internal temperature to be controlled at 22˚C ± 2˚C.

3.9.1.10 CMS Network Interface to PV Plant Sub-System (or Black Box Systems)

- **Meteorological System**

  The meteorological system commonly referred to as ‘weather station’ containing specific instruments will be installed at specific positions on the PV plant to provide environmental data. The instruments at specific location of the plant will connect to its dedicated data acquisition system. Each weather station data acquisition system will communicate to the CMS server via the optical fibre ring network.

  The meteorological information that is required to be measured by specific instruments is described:

  Global horizontal irradiance (GHI) is measured by the Pyranometer and irradiance at the Plane of array (POA) will be measured by a pair of Calibrated solar cells. The output parameters from both instruments are an analogue (4-20mA) current reading that is converted to watts per square meter (W/m^2).

  A pair of calibrated cells is installed to determine the cleaning frequency of the PV panels on the plant. This is achieved by cleaning one solar cell while leaving the other cell dirty. A comparison is made with the output irradiation of both cells to determine what percentage of power is lost when the PV panels are soiled with dust or silt.

  The speed and direction of the wind that blows along the horizontal plane of the plant is measured by an anemometer and a wind vane. The main purpose of these sensors is to record the wind situation at specific site and the data from these sensors along with others will be useful to estimate the solar irradiation at module plane, if the installed reference cells are malfunctioned. Furthermore, the data from these sensors can be useful to support any claim during operation if the failure is due to wind related issue. The output parameter from the anemometer is an analogue (4-20mA) current reading that is converted to meters per second (m/s) or kilometres per hour (km/h). The output parameter from the wind vane is a 4-20mA reading that is converted to an angle (0-359˚) in degrees with 0˚ being true north.

The rainfall on a PV plant is measured by a tipping bucket rain gauge which uses a tip switch to count the number of droplets. The digital pulses are transmitted to the CMS server to be converted to millimetres (mm) of rainfall.

Ambient air temperature and relative humidity measurement is done to record the meteorological condition of the site. Panel surface temperature data is used when verifying the short term performance against the long term guaranteed performance (commonly called temperature correct performance ratio). The PT100 temperature sensor is installed upright in a secure housing to measure the ambient air temperature by outputting a 4-20mA signal. The PT100 sensor is installed at the back pane of the PV panel to continuously measure the surface temperature of the panel. The performance of the semiconductor cells in the PV panels changes as the temperature of the material change.

The data from meteorological instruments is normally communicated to a weather station or data acquisition system to be processed. The system is an intelligent, black box unit that can communicate with the CMS server. The weather station will connect to the CMS network using either RS485 or optical fibre.

The data from reference cell and PT 100 (module back- on special case) will be used directly to evaluate the plant performance. A Pyranometer and ambient temperature will be measured to have a record of meteorological status on project location and these data will be used to cross check the reading from reference cell (especially from Pyranometer). The measured meteorological parameters will be stored on at least 15 minutes inverter basis.

- **Central Inverters**

  The inverters are intelligent devices that can communicate data to the CMS servers. Inverters include their own built-in control and protection system. The on-site CMS will interface to the inverter control system to monitor data in real time. Open/close commands will be sent from the CMS thin clients to start/stop the inverter from the control room. The communication interface between the inverter and CMS is Ethernet, RS485 or optical fibre.

- **Intelligent DC String Combiner Boxes (SCB)**

  DC string combiner boxes used in solar PV plants basically combine multiple parallel strings from the PV array. The combined DC power is supplied over a single DC cable to an inverter or a second combiner box. Intelligent DC combiner boxes are installed with measurement and data communication capabilities to monitor individual string current, average DC voltage, isolation switch status and internal temperature of the box. Each SCB will connect to the CMS network using either RS485 or optical fibre.

- **Switchgear**

  Medium voltage (MV) switchgear panels (RMU) at the inverter cabins will be controlled using motorised controlled circuit breakers (MCCB). The plant CMS will interface to the switchgear panel to monitor the status of the MCCBs. Command to open/close each MCCB will be initiated via the plant CMS at the control room. The switchgear panel will include 24 Vdc interposing relays to allow the CMS to interface using digital IO cards with potential free terminals. This method is commonly known as hardwiring.

  Emergency stop/trip signals will be hardwired from the push button switch directly to the switchgear breaker. No emergency trip/stop commands will be communicated to the switchgear via the CMS network.

- **Energy Meters**

All RMU integrated energy meters are required to communicate data to the on-site CMS using either optical fibre or Ethernet.

- **Protection relays**

  Each PV block will be equipped with IEDs at the POC switchgear. All these protection relays are required to communicate data to the on-site CMS using either optical fibre or Ethernet.

- **Uninterruptable Power Supply (UPS)**

  An uninterruptable power supply (UPS) system, including battery backup, will provide 230 Vac power to the CMS servers and network equipment inside the server room, control room and CMS network panels of the Project.

  The UPS system will have the capability to communicate to the CMS server via the core network. The following parameters are required as a minimum:

  - Warning indications and alarms in an event of UPS failure or fault conditions,
  - Remaining battery life in terms of percentage (%) and remaining minutes of supply,
    Safe shut off commands to the CMS server when the battery life reaches the reserve level of 25%.

- **Potable Water and Sewage Tanks**

  Where applicable, the potable water storage tank and sewage storage tanks will include continuous levels sensors that are required to be monitored at the CMS. The level sensors will interface to CMS network panel closest to the tanks. IO cards will be installed to sample the data from the level sensors.

- **Fire Detection System**

  A fire detection system (FDS) will be installed. The plant FDS is required to be monitored remotely and on-site. A detailed fire risk assessment, Eskom Fire Protection – Detection Assessment Standard 240-54937439, will be conducted to determine the type and number of sensors, warning indicators and fire panels that will be required for the Project. The Fire detection system need to comply with SANS 10139 (latest revision) or equivalent accepted standard as well as the Eskom Fire Detection and Life Safety Design Standard 240-56737448. The following areas of plant require FDS as a minimum:

  - All inverter cabins,
  - O&M building rooms

  The number of fire panels used will be dependent on the distance between each equipment room and the limitation of the data communications. Based on RS485 communications between a fire panel and associated sensors, it is preferred that the following number panels be used per plant area:

  Each fire panel is required to have an on-board display for local monitoring. Each fire panel is required to be monitored at the PV plant control room and remotely. It is preferred that each fire panel will interface to the closest CMS network panel using either RS485, Ethernet or optical fibre. Each fire panel will operate as a standalone unit to ensure that local alarms are maintained in the event that communication between panels and control room fails. Each FDS will be powered from a local UPS either at the inverter cabin or switchgear room.

3.9.2 CMS Network Interface to 3rd Party Networks

Remote Access to the PV plant CMS Network

Remote monitoring is achieved through an IT/OT interface and required DMZ, as per Eskom's 32-373: Information Security – IT/OT and Third-Party Remote Access Standard and 240-79669677 DMZ Designs for OT Systems.

Remote control and monitoring is required at the O&M Contractor's offices during O&M period of commercial operation. The detailed design of the IT architecture and required topology, as well as the required cyber security designs and requirements will be achieved through a collaboration effort between the appointed EPC contractor and Eskom stakeholders.

The O&M contractor and authorised Eskom users will be granted access to the plant CMS network via this interface to monitor the plant in near real time. The remote access will be via a firewall to establish a secured virtual private network (VPN) connection using the IPSec protocol.

The following table summarises the local and remote control.

Table 28: Local and remote control

	Control vs. Monitoring	Location	Communications	Alarm Response & Fault Reporting
Local (on-site)	Full control and monitoring. Alarm + fault response	On-site control room	OT network	Full functionality as per alarm philosophy and fault detection
Remote (off-site) **EAL offices**	Only monitoring No control Alarm + fault response	**EAL offices (Midrand)**	Achieved via an IT network where an IT/OT interface is at plant. DMZ, firewalls, cyber security – detail design to be by Eskom IT & Cyber Security	As per alarm philosophy and fault detection SMS/email of alarms, faults and fire detection sent to operational and maintenance personal
Regional Control	Limited control / monitoring. Grid Code compliance	Regional Control offices	Telecommunication through the substation	In line with the control / monitoring required
EPC O&M	Full control and monitoring. Alarm + fault response O&M period of commercial operation	TBD – EPC offices	Achieved via an IT network where an IT/OT interface is at plant. DMZ, firewalls, cyber security – design to be done with Eskom teams	Full functionality as per alarm philosophy and fault detection
Web-based client	Only monitoring. No control. Access to plant	Anywhere from Eskom LAN/business network	OPC via IT network.	Status reporting and when the plant overview is shown

	Control vs. Monitoring	Location	Communications	Alarm Response & Fault Reporting
	historian for data and reporting.			

3.9.3 CMS Power Supply and Power Distribution

The power source to CMS equipment will be either 24 V dc or 230 V ac. It is recommended at all 230 V ac equipment installed in the server room be supplied by a dual redundantly configured 230 Vac UPS with a battery bank to provide uninterruptable source of power for a duration of four (4) hours, immediately after the main 230 V ac supply to the UPS system is isolated. The purpose of the UPS system is to provide a regulated power source to sensitive CMS equipment. Furthermore, the UPS will continue providing regulated power to essential CMS equipment in order to ensure a safe shutdown of the CMS servers and thin clients when the main 230 V ac supply to the UPS is isolated. The dual redundant UPS system will be installed in a dedicated 19" cabinet inside the server room. The batteries will be sealed-type, deep cycle and free from hydrogen discharge. Batteries that discharge hydrogen must be installed in a dedicated battery room with adequate ventilation in accordance with Eskom standards. The following types of batteries are acceptable:

- Valve regulated lead acid (VRLA),
- Nickel Cadmium (NiCd), or
- Lithium Ion (Li-ion).

If during operation, the batteries reach a capacity of 25%, the UPS will send a command to the CMS servers and thin client PCs, to safely shutdown. The UPSs will include an on-board LCD panel to display the performance parameters of the system and an on-board audible alarm to buzz when the battery is running on reserve power or if there is a system fault.

Each CMS network panel and fire panel will be fed from the UPS that's located in each inverter cabin and control room of the Project. This ensures continuous supply of power to the core optical fibre ring network. DC-DC rectifiers (e.g. 110 V dc - 24 V dc) will be installed inside the CMS network panel and fire panel as required.

Electronic equipment such as weather stations and string combiner boxes will be fed from suitably rated 230 V ac - 24 V dc power supply units (PSU) that are installed inside the equipment itself. The PSUs will be fed from the local auxiliary power DB.

The power source requirement for the CMS system equipment is documented in the table below.

Table 29: CMS equipment power supply requirements

Control system equipment	Equipment room / location	Power source per device
CMS network panels	Inverter cabins	230 V ac (UPSs) per inverter cabin and DB
String combiner boxes	PV field	230 V ac from Aux. DB per cabin
Weather station (DAS)	Next to O&M buildings	230 V ac from Aux. DB per cabin
Fire panels (FDS)	Inverter cabins and O&M room	230 V ac (UPSs) per inverter cabin and control room
1 x 19" UPS cabinet	PV plant server room	230 V ac from PV Aux DBs located in the control room (Aux 1 and Aux 2)

Control system equipment	Equipment room / location	Power source per device
1 x 19” network/server cabinet - Redundant CMS and plant information servers - Redundant master switches - Common switch - GPS clock - Web server - Firewall & internet modem	PV plant server room	230 V ac (UPSs)
2 x thin clients	PV plant control room / server room	230 V ac (UPSs)
4 x KVM extenders	PV plant server room and control room	230 V ac (UPSs)
6 x 19” and 2x 40” monitors	PV plant control room	230 V ac (UPSs)
3rd party equipment		
Local security system cabinet	PV plant server room	230 V ac (UPSs)
IT/IM cabinet	PV plant server room	230 V ac (UPSs)

3.9.4 Control and Server Room Arrangement

The PV plant control and server room is expected to comply with the Eskom standards for Process control and ergonomic design. The existing Server room includes raised floors to allow for cable access into the network cabinets. Redundant equipment/servers are not to share the same server cabinet and are split over across two cabinets. The Server room is expected to cater for the following number of 19” floor standing network cabinets:

- 1 x CMS network cabinet (servers, thin clients, etc.),
- 1 x CMS network cabinet (network switches, splice trays patch panels),
- 1 x redundantly configured CMS UPS system cabinet,
- 1 x PV plant security system network cabinet,
- 1 x IT/IM network cabinet, and
- 1 x network cabinet for Eskom approved gateway/RTU (Grid code).

3.10 HEATING, VENTILATION AND AIR-CONDITIONING (HVAC) SYSTEM

The solar PV plant will be using the building infrastructure built for the wind farm as far as possible. This being the case, certain hardware to ensure continuous operation and security monitoring of the plant will still require continuous cooling. The servers installed to ensure this functionality is in the server room. The server room, office (including kitchen area and ablution facilities) and control room will be shared with the existing infrastructure for the wind farm.

A HVAC system is required for continuous temperature and humidity control in the server room.

The server room requirements are specified in the 32-894 Eskom Server Room and Data Centre Standard. The O&M PV storeroom ventilation is provided by a ducted extraction system and window extractor fans discharging contaminated air to outside with make-up air supplied from the surrounding areas via door grilles and ducted fresh air supply.

The site environmental conditions are as follows:

- Summer: 40°C DB
- Winter: 0°C DB
- Altitude: 32 m

The following general design criteria is applicable for HVAC system design:

- Air pressurization and filtration to be implemented to maintain good indoor air quality.
- Adequate fresh air for normal and emergency ventilation.
- Avoid refrigerants harmful to the ozone layer.
- Noise levels of HVAC plant to not exceed background noise levels.
- The operation of the HVAC system for the storeroom shall be manually operated when in use by staff and turned off when not in use.
- The split units will mitigate the risk of the unit being left on for extended periods of time or the unit automatically switching on after a power cut with the use of motion sensors, auto-control cards or other means that are suitable for the application
- All HVAC equipment that services the server room shall operate for 24 hours per day, seven days per week, and are to be supplied with electrical and mechanical redundancy.
- Duct work is to be externally insulated.
- Ducts are designed to low pressure standard. The criteria for duct sizing are pressure drop of 1 Pa/m for air flow up to 1 m^3/s and the criteria of 6 m/s for higher flow.
- The supply air flow for air conditioning and ventilation shall be calculated from the required heat removal and applicable temperature difference.
- The minimum air flow, where no heat load is present shall be 5 air changes per hour.

3.10.1 HVAC System Description

Outdoor filtered air is to be provided by means of fresh units which are connected to an external insulated galvanized sheet metal ductwork. Air is to be introduced into the space by means of constant air volume (CAV) diffusers/grilles.

O&M spares room ventilation is provided by a ducted extraction system and window extractor fans discharging contaminated air to outside with make-up air supplied from the surrounding areas via door grilles and ducted fresh air supply.

3.11 FIRE PROTECTION SYSTEM

The solar PV plant will be using the building infrastructure built for the wind farm as far as possible. The fire protection system in the existing O&M buildings to be reviewed for suitability where these buildings needs to accommodate PV plant. These fire protection systems must comply with the requirements of SANS 10400, SANS 246 and the Eskom Fire and Life Safety Design Standard (240-54937450). The complete fire protection system is to be designed, constructed, and equipped to satisfy the following requirements:

- Ensure protection of occupants (life safety).
- Minimise the spread and intensity of fire.
- Minimise and control the generation of fire and spread of smoke.
- Ensure sufficient building stability is retained in a fire; and to
- Provide adequate fire detection and fire extinguishing equipment, and access for fire brigade services.

3.11.1 Evaluation of suitable Fire Protection System options

SANS 10400, SANS 246 and the Eskom Fire and Life Safety Design Standard (240-54937450, revision 2) recommend that portable fire-fighting equipment should be installed to low risk buildings with minimum of 1-off 5 kg CO^2 (carbon dioxide) fire extinguishers per 50 m^2 floor area in control rooms.

The required fire protection system for the solar PV plant is a function of fire protection/detection assessment which is based on possible failure modes (electrical faults) that may result in a fire, and therefore can only be concluded during the detailed design phase of the project.

3.11.2 Fire Protection System Description

The envisaged portable fire-fighting equipment to be provided is as follows:

- 2-off 5 kg CO_2 (carbon dioxide) fire extinguishers will be provided to service the O&M building (control room, office, ablution facilities, server and equipment room).
- 2-off 5 kg CO_2 (carbon dioxide) fire extinguishers will be provided to service the spares storeroom.

The required fire protection system for the solar PV plant is to be determined through a fire protection/detection assessment by checking all possible failure modes in a PV system during the detailed design phase.

3.11.3 Fire Safety Risk Assessment

A fire protection/detection assessment will be conducted by the EPC Contractor during the detailed design phase of the project.

3.12 WATER SUPPLY AND RETICULATION SYSTEM

The water supply and reticulation systems comprise of process water for the washing of panels. Potable water for ablution and kitchen facilities will be catered for by the existing wind farm

3.12.1 Process Water Supply and Reticulation

Process water supply and reticulation is required for panel washing and dust suppression activities.

The quality of water required for panel washing will be determined based on the requirements of the panel manufacturer. It is envisaged that the water quality for panel washing will be at potable water quality at a minimum. PV panels to be cleaned when required. The preliminary estimation is that panel washing will occur twice a year in June and September or when reference cells show a difference of GHI measurements of greater than 50 Wh/m^2. The amount of water required for cleaning each module is to be confirmed during the detailed design stage of the project.

3.12.1.1 Process Water Supply Options

The following options can be considered for the site and confirmed during the detailed design phase of the project:

- Tap off from the municipal water pipeline to provide the site with process water.
- Process water is to be trucked to the solar PV plant in tanker trucks and used via onsite reticulation system when required (panel washing, dust suppression).

Borehole water is not considered as a viable option as the borehole water on site has high mineral content and would require a water treatment plant.

3.12.1.2 Process water system description

The process water must be stored and reticulated across the solar PV plant as required. Taps shall be located at various locations in the solar PV plant. The maximum distance between the tap and point if use is 50 m. Suitable treatment processes may be required to ensure the process water is at the required quality for panel washing, based on requirements from the panel manufacturer.

3.13 SEWERAGE AND WASTE DISPOSAL SYSTEM

The solar PV plant will be utilising the existing building infrastructure built for the Sere Wind farm as far as possible. Hence, personnel will be utilising the ablutions and kitchen facility within the existing O&M building. The size of the existing sewage septic must be verified if adequate for the additional users.

If under sized, the following options are available:

- Re-size and install a larger tank to accommodate both Sere Wind Farm and additional Solar PV Plant contributors
- Connect an additional small septic tank to tie into the existing system
- Change the desludging/emptying process to be more frequent

From the above options, it would be more feasible to replace the existing tank with a tank of a larger capacity if required.

However, should a new Operating and Maintenance building be constructed, the following would apply to sewerage and waste disposal.

If adequate municipal infrastructure exists in the area, then the sewage and waste from the O&M building will be reticulated to tap into such infrastructure.

Alternatively, a sewage septic tank that is imbedded in the ground will be installed. The sewage septic tank will be linked with pipes from the kitchen and ablutions in the O&M building. The sewage septic tank will have an overfill detection and protection to avoid environment contamination.

As a minimum, the tank's design should meet the following requirements:

- The tank shall be constructed and designed in accordance to the information contained within SANS 10400-P: 2010 standard.
- The tank shall be designed such that all requirements of the Occupational Health and Safety Act (Act No. 85 of 1993) and its regulations are adhered to.
- The inlet should be designed such that blockage by the scum layer is prevented.
- The depth of the tank should be designed in line with acceptable standards.
- The tank shall be designed with two compartments to allow for periodic desludging. The tank should be easily accessible.

The tank must always be watertight and shall not allow for any storm water inflow. The tank must be constructed of materials which are not susceptible to excessive corrosion. The interior should be plastered with a waterproof material. Adequate water supply must always be available for use with a water connection point available within the vicinity of the tank.

3.14 CIVIL AND STRUCTURAL DESIGN

3.14.1 Civil infrastructure

The EPC Contractor will be responsible for performing:

- Geotechnical investigations and assessments
- Site earthworks
- Mounting Structures
- Foundations
- Buildings and structures
- Roads and Storm water
- Parking areas
- Fencing and access gates

From previous studies conducted it was found to be feasible to utilise the existing building infrastructure built for the Sere Wind farm for the solar PV plant as far as possible. The site operations and buildings required for Sere PV Plant – Phase 1a project must be optimised with the existing Sere Wind Farm e.g. monitoring from a common control room, common workshops, common ablution, kitchen, common office area, etc.

The Civil Works must interface with the current infrastructure at the existing substation.

The high wind speeds at the Sere site could impact on the PV mounting structure and foundation requirements. It is recommended that this is considered in the structural design.

Sere is located on the west coast. The coastal location could impact the corrosion protection requirements for PV modules, equipment, and structures, as well as the required module cleaning frequency due to soiling from salt deposits. It is recommended that this is considered in the design stage of the project.

The design life of the civil works to be a minimum of 25 years

3.14.1.1 Mounting Structures/Foundations

The detailed design for the foundations and mounting structures shall be based on the findings from a geotechnical study, requirements, and conditions from the EIA approval, as well as considering applicable design loads and standards.

The PV Modules would be connected in series to form strings. PV ground mounting structures and foundations would be used to fix the PV modules to the ground at the appropriate orientation to the sun. The PV mounting options would include fixed tilted mounting systems and tracking systems. Tracking systems could be single axis or dual axis systems. The use of these systems usually allows the plant layout to be easily adaptable to the terrain.

The simplest and most common installation for large scale free field mounted PV systems is fixed mounted systems, where groups of PV modules, i.e. PV arrays, are mounted on a structure with fixed slope or inclination. These structures are usually steel structures. The height of the structure can be up to 2.5 to 3.5 m. The width of the structure could be up to 3.5 m wide.

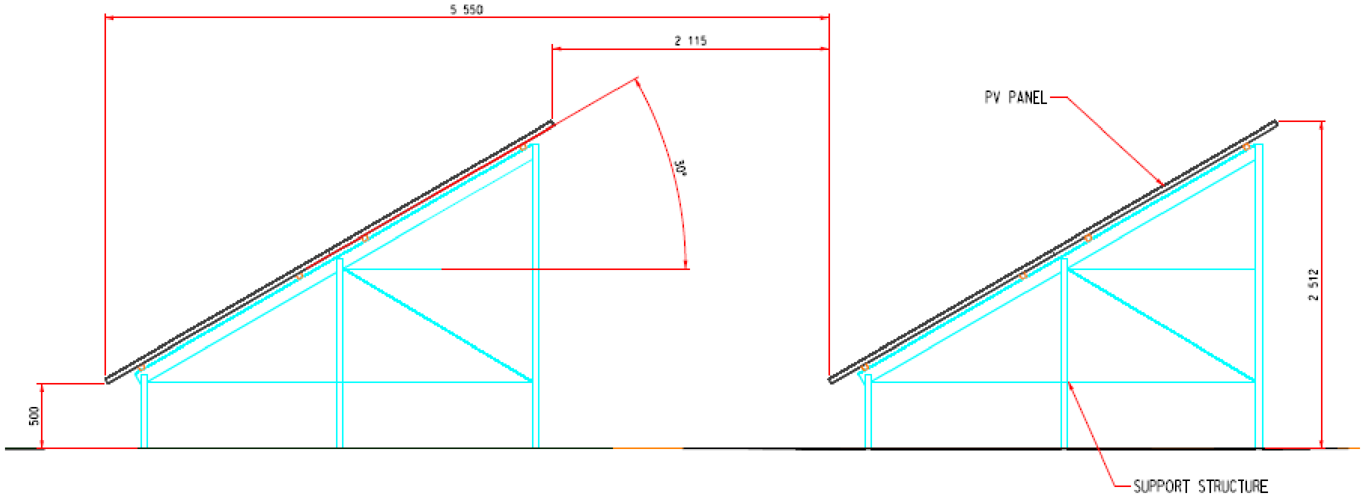


Figure 23: Typical Fixed Mounting Structure

The project foresees that the contractor will propose the appropriate mounting solutions for the project along with detail design of the plant. The contractor will optimise on the plant layout, configuration, and panel size to achieve the highest output based on the land, topography, rainfall patterns, ambient temperatures, aerosols and dust particles. The EPC contractor must take cognisance as the Sere Wind Farm may present safety and damage concerns for a PV facility that is located in proximity to the wind turbines. It is recommended that this is considered in the design and final layout. Geotechnical investigations will be required to determine the geotechnical parameters and to inform the foundation design of the mounting structures. The foundation design could either be of the type where the mounting structure is piled into the ground (no concrete foundations), pad footings or ballast foundations.

3.14.1.2 Foundation Options

There are three foundation techniques which are common for PV installation, namely:

a. Screwed or rammed piles

b. Piles in pre-drilled holes with backfilling or concrete

c. Ballast foundations

Option 1 - Screwed or Rammed piles

Geotechnical criteria for screwed or rammed piles

Screwed or rammed piles are the cheapest and preferred founding methodology for PV mounting structures and are therefore always considered first when investigating the founding conditions of a site. The following criteria are investigated to determine if the conditions are adequate for a screwed or rammed pile foundation type:

- If bedrock is present too close to the surface this option becomes impractical as the piles generally can't penetrate the bedrock and a sufficient founding depth cannot be reached.
- Consideration needs to be given to the layer of topsoil (if any) to determine if it can take any static loads transferred from the posts.
- The founding rocks or soil must be capable of tolerating all loads transferred from the posts.
- Generally, the depth to which the posts should be founded is determined by the horizontal forces (wind) at the upper end of the post, which are to be transferred into the ground. The upward force or

uplift of the structure due to wind loads also need to be considered when determining the depth to which the piles will be screwed or rammed.

Construction Methodology for screwed or rammed Piles

Screwed Piles or earth screws

Earth screws are embedded in the soil the same way that wood screws are embedded in wood and provide resistance to loads in much the same way. Maximum allowable uplift forces for a given earth screw size are determined primarily by the soil's shear resistance and the depth to which the earth screw is sunk. Figure 24 show a typical earth screw and the machine used to screw it into the earth.

Figure 24: Typical ground screw pile

Rammed Piles

The anchoring of the pile driven profiles in the soil is carried out using special terrain-friendly hydraulic pile drivers. This pile-driving technique is especially suitable for utility scale plants. Depending on the terrain, a pile-driving performance of 250 piles/day can be achieved. Pile-driving on difficult terrain (stones, etc.) is also possible. In case of rocky subsoils, the machine can be additionally equipped with a drilling unit. Figure 25 show a typical machine used to drive the piles into the ground and the finished product rammed piles.

Figure 25: Typical Rammed Piles

Option 2 - Piles in pre-drilled Holes with Backfilling or Concrete

Geotechnical Criteria for pre-drilled holes with backfilling or concrete

Geotechnical conditions may result in the need for foundation holes to be pre-drilled prior to ramming the piles and backfilling with concrete or some other aggregate. These conditions are as follows:

1. The presence of bedrock close to the surface; and
2. Inadequate sheer strength of the founding soil.

Construction Methodology for pre-drilled holes with back filling or concrete

Pre-drilled holes with backfilling

A hole is drilled not more than 5 cm wider than the breadth of the steel profile and the cuttings that result from the drilling process remain in the hole. If a small amount is missing from the drilled hole, it is replaced by a suitable material such as concrete recyclate or chalky gravel. The filling is not compacted before ramming the pile. The steel profiles are then to be rammed into the holes to the necessary depth, and during this process the filling is compacted and the transfer of forces from the post to the wall of the drill hole is improved.

Pre-drilled holes with concrete

If ramming or screw posts are not able to penetrate the bedrock, pre-drilling and filling the boreholes will have to be done. This is done using the same approach as above, however the cuttings are removed and the voids are grouted up with the post rammed in place. Figure 26 shows a typical concrete filled foundation.

Figure 26: Typical concrete pile foundation

Option 3 - Ballast Foundations

Geotechnical Criteria

Ballast foundations are the most expensive and least preferred founding methodology for PV mounting structures. The only geotechnical consideration is the bearing capacity of the soil which is the maximum pressure that the soil can bear without compacting so much that the structural integrity or functionality of the structure being supported is compromised.

Construction Methodology

The primary purpose of the concrete foundation is to provide sufficient weight to counteract any lift forces generated by the wind loading on the modules. Concrete slabs are cast either above ground or in shallow excavations. The Mounting structures are then mounted to the concrete slabs by using fixings cast into the slab or base plates bolted onto the slab. Figure 27 shows typical ballast foundations for a ground mounted PV facility.

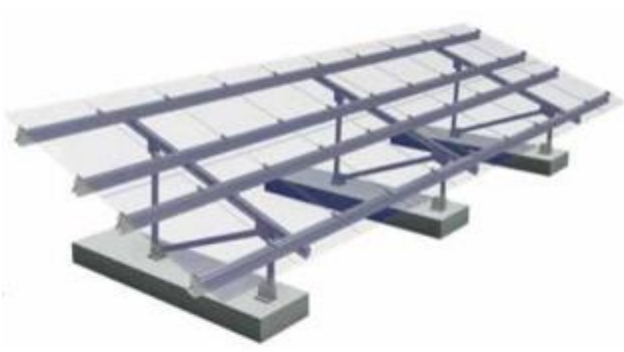



Figure 27: Typical Ballast Foundation

Selected Option - Foundation

The present geotechnical study conducted for the Sere Wind Farm is insufficient to make a recommendation on foundation design, therefore, a detailed geotechnical study shall be performed by the Contractor for the Project and the foundation design shall be prepared based on the findings from the study.

Associated Structures, Buildings and Roads

Infrastructure and associated utilities would consist of roads, storm water infrastructure, security fencing, buildings, cable trenches and meteorological measuring stations. Switchgear and server rooms to be constructed from brick and concrete. Concrete/brick trenches for cabling and services need to be provided for where required. Transformer bays to be designed with appropriate bunding. This would entail oil holding tanks if oil filled transformers are used. The transformer bays and bunds must be constructed from reinforced concrete. The foundation design for all buildings and structures will be based on the geotechnical investigation as well as the required loadings.

The PV Plant Security Lighting, to entail steel mast or concrete towers on concrete pad foundations. Lighting masts to have reinforced concrete pad foundations. A security/access control building to be positioned at the main gate of the PV Plant.

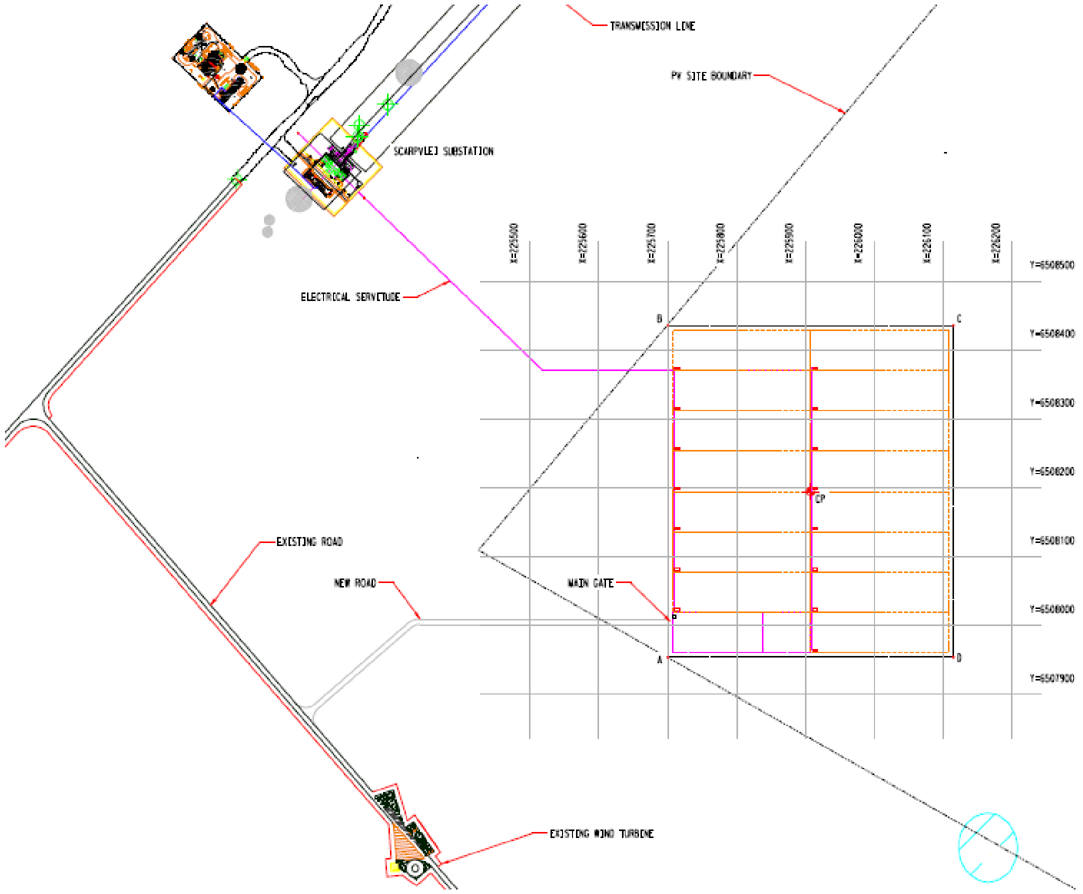


Figure 28: Proposed site Layout

The Solar PV Plant will be utilising the existing building infrastructure built for the Sere Wind farm as far as possible. This would consist of an Operating and Maintenance building to house a PV control room, offices, ablutions, and kitchen. This is to be confirmed at design stage and the suitability of utilising existing building space. The buildings to consist of brick structures on reinforced concrete strip foundations. A Stores building for storage of PV spare panels and parts and workshop building to undertake any maintenance work would be required. The workshops and stores building would consist of steel portal framed structure with brick infill panels. The workshop and stores building could incorporate an overhead crane. The O&M buildings will be located close to the entrance. Installation of a meteorological stations which includes any associated civil work for phase 1a.

The area is water scarce which needs to be considered in determining the cleaning method/technology of the PV panels. The storage and reticulation of process water must be considered in the civil design. Storage water tanks and foundations would be to manufacturer's specifications. The water storage tanks to be confirmed at design stage and the tanks sized accordingly. Water reticulation piping in the PV plant area is required and if deemed necessary at the O&M buildings then further reticulation piping would also be required. The process water must be stored and reticulated across the solar PV plant as required.

Roads

The road infrastructure will be designed in such a manner as to comply with the relevant legislation and regulations.

It is expected that the EPC Contractor will perform pavement designs for the access road and internal roads. The pavement designs shall comply with the Eskom Road Specification Manual (240-84418186).

The geometric properties of the roads shall be to the safest and optimal geometric design possible and shall comply with the Eskom Road Specification Manual (240-84418186).

As a minimum the roads will entail:

- Construction of a new gravel access road
- Perimeter ring road around the PV plant.
- Gravel access roads to inverters and transformers.
- Gravel internal roads for maintenance purposes.

The road widths and pavement structure to be confirmed at design stage.

The EPC Contractor will be responsible to conduct the required geotechnical investigation and survey, to enable them to perform the designs for the access road and internal roads.

The gravel roads surface finish shall be finished to minimise dust.

The roads will be designed for abnormal vehicle loads where required.

Road access to Inverter/MV switch-rooms must cater for a truck with a crane.

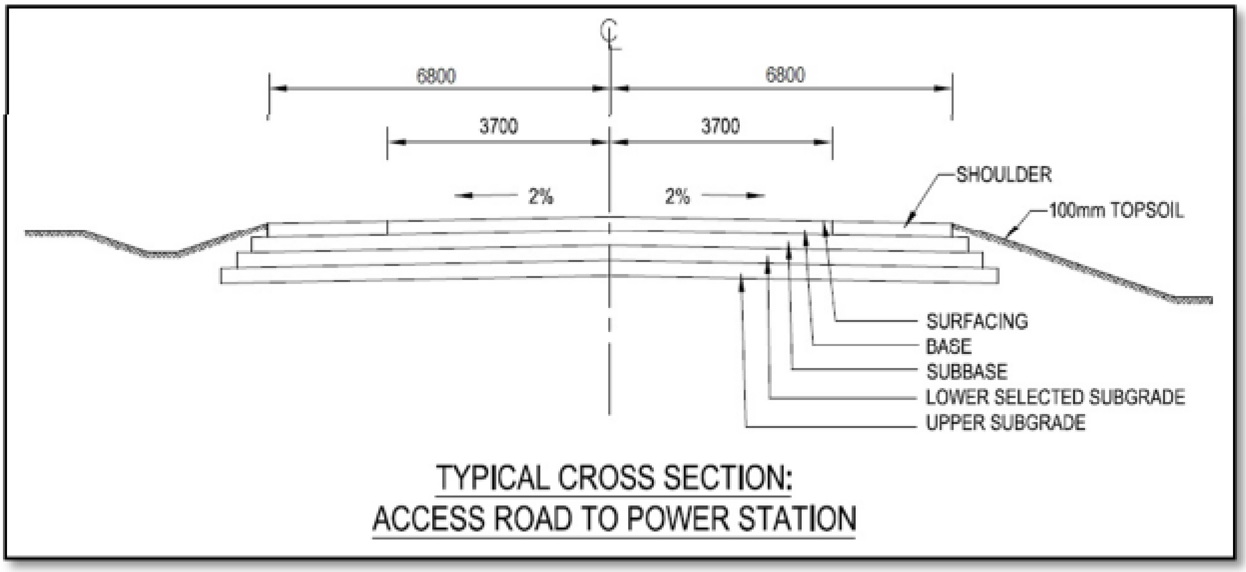


Figure 29: Proposed cross fall for access road

3.14.1.3 O&M Building:

The feasible option is to utilise the existing O&M Building. If an additional O&M Building(s) is required, it is to have the following minimum facilities.

- Control room for 2 employees (For employees to view status of plant equipment, air-conditioned)
- 1 x small office
- Server room and security equipment room (Air-conditioned room for sensitive electronic equipment)
- Ablution facilities

- Storeroom (for the storage of spare solar panels and electronic equipment)

The control room with regards to operator interface shall be designed to ergonomic principles and good Solar Power Plant practice.

All civil infrastructure and security requirements associated with the O&M building must be catered for during the detail design. This includes but is not limited to cable routings and trunking/racking.

3.14.1.4 Construction and Maintenance Access:

Access for construction equipment and materials during the construction phase must be provided for in the design. Construction of a gravel perimeter road, access roads to inverters and transformers, gravel internal roads for maintenance purposes must be considered. The gravel road shall be finished to minimise dust. The Contractor shall prepare the detail design with requirements from the works information as well as with the requirements from EIA approval. Suitable drainage system for the site shall be designed and constructed according to the approved environmental permit and Water Use License permit.

3.15 TEST AND COMMISSIONING

The commissioning strategy for the project includes different tests and inspection that will be performed before construction, during construction, on completion and after completion. These includes:

- Factory Acceptance Test
- Site Acceptance test
- Mechanical Completion Test
- Electrical Completion Test
- Provisional Acceptance Test, and
- Final Acceptance Test

Factory Acceptance Tests will be performed on major plant components before the delivery of components to the site. The objective of this test is to ensure the quality of the products that will be used for the project. PV Modules, Inverters and Transformers are considered as major plant components in this project. These tests will be performed at manufacturer/suppliers' premises. The Contractor shall organize the necessary requirements for the test. The test type and requirement for each test type will be detailed in Works Information. The Employer's representative will inspect and verify the quality of components, according to requirement set in Works Information.

Site Acceptance Tests will be performed on site upon the delivery of components on site. The test verifies that all components that are delivered to the site are free from any defects and includes all warranties, certificates, and technical documents.

Mechanical Completion Test will be performed once the plant is completely constructed. This test will be performed by the Contractor with Employer witnessing the tests. Visual inspection on plant component, verification of plant according to design document and availability of all project documents (guarantees, technical data sheet, and component manual) will be checked during the Mechanical completion test. Upon the successful completion of this test, Mechanical completion certificate will be issued, and the Electrical completion tests will be followed.

During Electrical completion tests, functional measurement of components (such as string voltage current tests, polarity test, infrared scanning, etc.) including safety checks (earthing, over voltage/over current protection) will be performed and proper functioning will be verified. The tests will be performed according to relevant IEC standards; IEC 62446 and IEC 60364-6, common practice in PV commissioning as well as the requirements of the South African Grid Code.

During, Provisional Acceptance Test (PAT), performance (performance ratio) and plant availability will be verified against the respective guaranteed values from the Contractor. The Contractor shall provide such guaranteed values along with their bidding documents during the tendering period. Upon the successful completion of PAT, the Substantial Completion Certificate will be issued.

Final Acceptance Test shall be performed over a predefined period, after the issue of substantial completion certificate. Plant performance ratio and plant availability will be verified during Final Acceptance Test along with visual inspection tests and some functional tests.

The tests during commissioning will be performed according to relevant IEC standards and common best practice in PV industry. Training to the Employer's O&M staff will be performed before the start of commissioning activities. The details on commissioning procedure will be included in the Works Information document.

3.16 COST ESTIMATION

This section indicates the determining factors to derive a cost estimate for the installed PV installation. The LCOE formula has many finance variables which require further investigation. The LCOE of a PV plant is generally determined by the following equation:

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where, I_t, M_t, F_t and E_t represent the investment cost, operating and maintenance cost, fuel cost, and electricity generated in year (t), respectively. r and n represent the discount rate and plant's lifetime, respectively. The aim of this concept design is to determine the cost estimate for the installation/investment (CAPEX) and operating and maintenance (OPEX) of the plant. The following parameters are of interest listed in Table 30.

For the past 10 years, the associated cost to PV has reduced drastically. Therefore, it is important to have an accurate costing benchmark for the analysis. The latest reliable reference document found in the literature study was released by NREL, "*U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020*" [18]. Another supplementary reference in the South African context was presented at the 27th AMEU Technical Convention in 2019, "*Price parity of solar PV with storage*" [15].

Table 30: Financial parameters

Parameter	Description
Installed Cost	The cost associated to the installation of a typical utility scale PV plant.
Yearly Operating Cost	The cost associated with the yearly operation of the plant, and the replacement of components, i.e. inverter every 10 years.
Cost Estimate	Installed and yearly operating cost in relation to the total energy yield.

The biggest challenge found in the literature review is that reliable references, such as Lazard, IRENA, EPRI and Fraunhofer report directly on the LCOE for PV installations. Often a constant factor installed cost (R/MW) is applied for utility scale PV systems, with a different installed cost associated with commercial and residential systems. A constant factor installed cost model is not considered as a true representation since it does not consider the specific cost reductions experienced as the size of the plant increases. This is best represented by Figure 30.

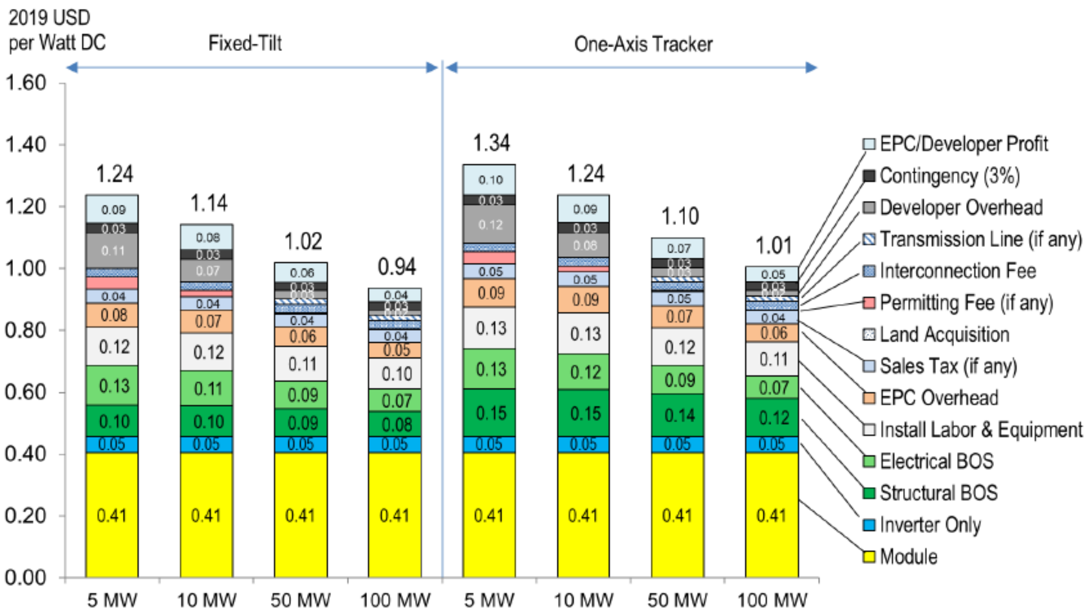


Figure 30: Utility-scale PV total cost (EPC + developer), 2019 USD/WDC [3]

It is worth noting, that the $/W for the module and inverter stay fixed for any plant size, whereas other specific costs reduce with an increase in capacity. This relationship in the variance in specific cost as the plant size increases can therefore not be accurately represented by a constant factor.

Due to the economies of scale, there is a cost saving from increasing the size of the system. Scaling up the system size from 50 MW to 100 MW reduces specific costs in several ways; per-watt Balance of System (BOS) costs are reduced due to bulk purchasing, labour costs benefit from learning-related improvements for larger systems and EPC overhead and developer costs are spread over with more installed capacity. The effect of the economies of scale is represented in Figure 31.

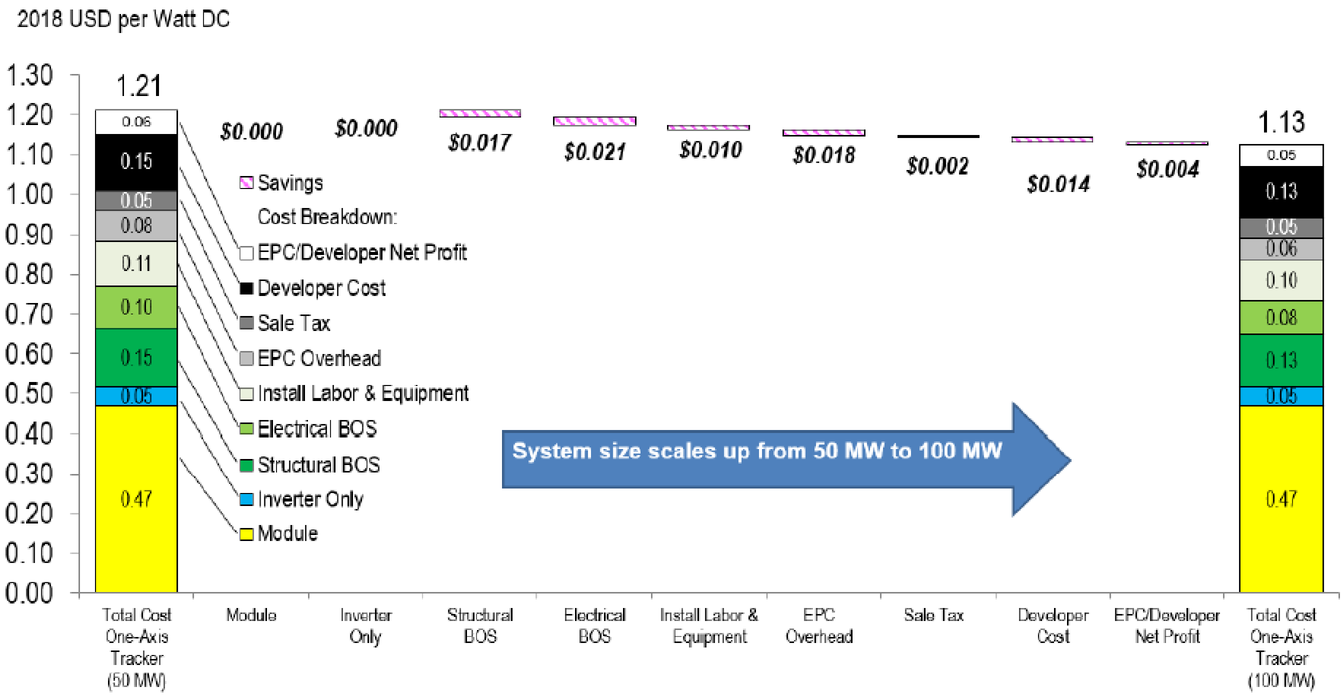


Figure 31: System cost reduction from economies of scale [4]

3.16.1 Fixed mounting PV cost estimate

The costing information used in this report was derived from the Utility-scale PV Cost data 5 MW to 100 MW, the Commercial ground-mount PV system cost data for 1 MW and 2 MW and the system cost reduction from economies of scale. The data is presented in Figure 32. The derived trendline was converted to South African Rands, see Figure 33, and correlated with the cost as presented in Figure 32.

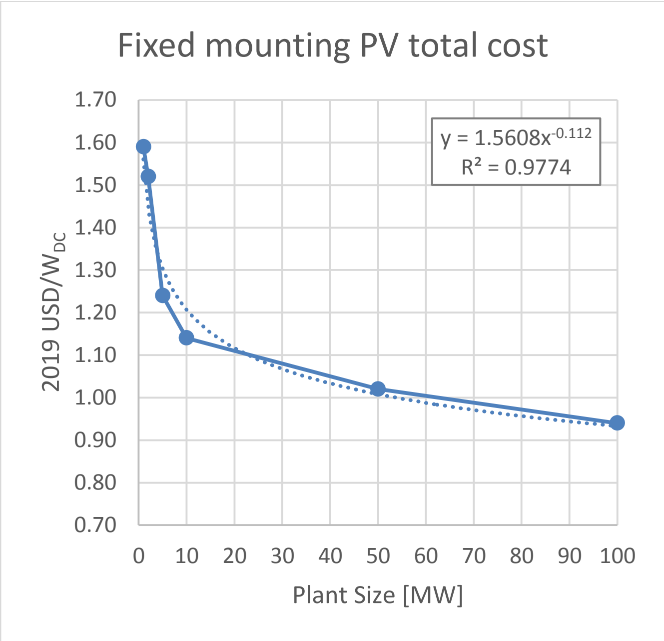


Figure 32: Reference costing (USD-2019)

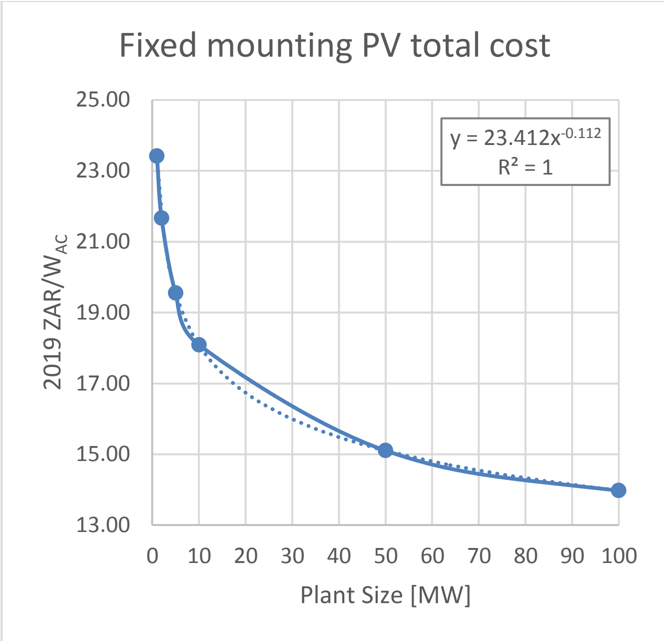


Figure 33: Reference costing (ZAR-2019)

The average specific costing presented in [15] for a 2 MW to 100 MW in 2019 is R14.43. In comparison, the costing curve for a 50 MW plant, results in a specific cost of R15.00. The financial parameters used to derive the cost estimate is presented in Table 31.

Table 31: Financial parameters used to derive the cost estimate

Parameter	Value	Unit
Total installation cost	23.412 x (Size of plant [MW])$^{-0.112}$	R
Operating and maintenance cost	1.5% of capital cost per year	R
Inverter replacement cost	3% of capital cost every 10 years	R
Cost Estimate	*From simulation results over lifetime of plant *0.5% degradation rate for PV modules per year	MWh

3.16.2 Single-axis tracking PV cost estimate

The same methodology applied to the cost estimate for fixed mounted PV systems was applied to single-axis tracking PV systems. The cost estimation curves are presented in Figure 34 and Figure 35.

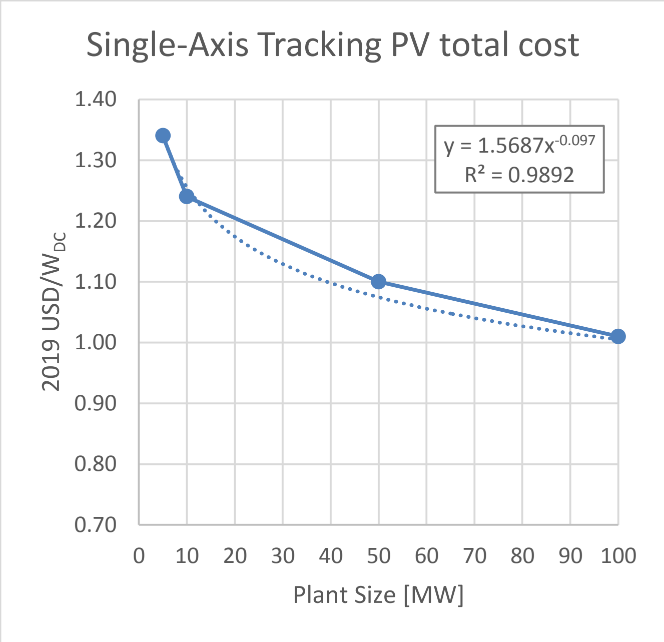


Figure 34: Reference costing (USD-2019)

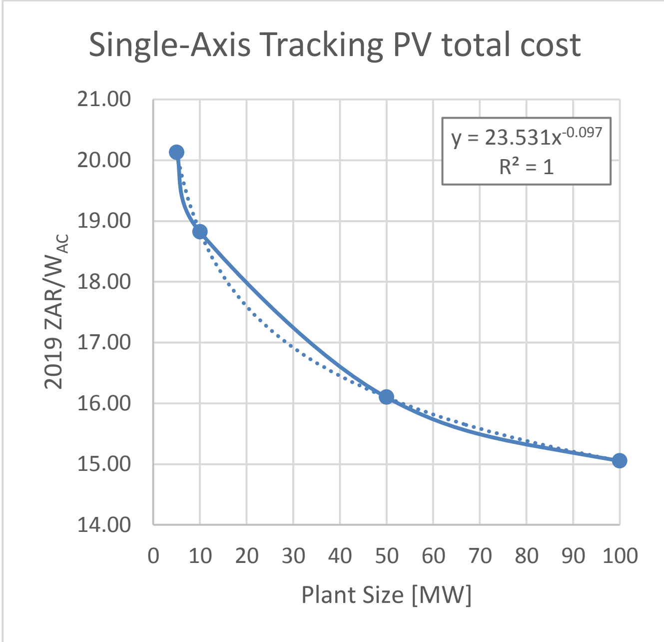


Figure 35: Reference costing (ZAR-2019)

Table 32: Financial parameters used to derive the cost estimate

Parameter	**Value**	**Unit**
Total installation cost	23.531 x (Size of plant [MW])$^{-0.097}$	R
Operating and maintenance cost	1.5% of capital cost per year	R
Inverter replacement cost	3% of capital cost every 10 years	R
Cost Estimate	*From simulation results over lifetime of plant *0.5% degradation rate for PV modules per year	MWh

3.16.3 Cost estimate

The Cost Estimate [R/kWh] is presented in the following equation:

$$Cost\ Estimate = \frac{Total\ Installation\ Cost + \ O\&M\ per\ year\ Cost + Inverter\ Replacement\ Cost}{Total\ Energy\ Generated}$$

Table 33 : Cost estimate for fixed and tracking systems

Options	**Plant Size**	**Curtailment**	**CAPEX**	**OPEX**	**LCOE (R/kWh)**
Option 4	14 MW tracking	YES	255 million	110 million	0.47
Option 4	14 MW tracking	NO	255 million	110 million	0.43
Option 3	16 MW fixed	NO	274 million	119 million	0.46
Option 3	16 MW fixed	YES	274 million	119 million	0.49

3.17 CODES AND STANDARDS

This section provides an overview of the standardisation approach for the design, the design Codes and Standards considered for the plant design. With respect to the multidisciplinary structure of PV projects various standards and codes have to be applied within the project lifecycle, particularly in the design and construction phase focussing on electrical interconnection, civil works, regulatory national framework and C&I system. A summary of subject's codes and standards have be considered for is given below. *The Contractor shall consider the latest issued standards applicable during the execution of the Project*:

3.17.1 Civil and Structural works

- SANS 10400 - Code of Practice – The Application of the National Building Regulations
- SANS 10100 – The structural use of concrete.
- SANS 10160 – Basis of structural design and actions for buildings and industrial standards.
- SANS 10162-1 – The structural use of steel Part 1: Limit states design of hot-rolled steelwork
- SANS 10162-2 – The structural use of steel Part 2: Limit states design of cold-formed steelwork
- SANS 10162-4 – The structural use of steel Part 4: The design of cold-formed stainless-steel structural members
- SANS 10021 Ed4.0 – The waterproofing of buildings (including damp-proofing and vapour barrier installation
- SANS121:2011 Ed2 – Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
- SANS 2001 – CS1 Ed.1.01 – Construction works Part CS1 – Structural steel works.
- SANS 1921-3 Ed.1 – Construction and Management requirements for works contracts – Part 3 Structural steel works
- SANS 1200H Ed3 – Standard specification for Civil Engineering construction - Structural steel work installation
- SANS 1200HC - Standardized specification for civil engineering construction Section HC: Corrosion protection of structural steelwork
- SANS 2001 – Construction
- SANS 10163-1- The Structural use of Timber Part1: Limit-states design
- SANS 10163-2 - The Structural use of Timber Part2: Allowable stress design
- SANS 10161- The design of foundations for buildings
- SANS 10164-1 - The structural use of masonry Part1: Unreinforced masonry walling
- SANS 10164-2 - The structural use of masonry Part2: Structural design and requirements for reinforced and pre-stressed masonry
- SANS 1200 Ed3 – Standard specification for Civil Engineering Works

3.17.1.1 Roads

- T.R.H. series: "Technical Recommendation for Highways
- T.H.M series – Technical Methods for Highways
- UTG series: Urban Transport guidelines
- SANS 1200 – Standardized specification for civil engineering construction
- SANS 1200 LD - Standardized specification for civil engineering construction Section LD: Sewers
- SANS 3001 – Civil engineering test methods
- COLTO : standard specifications for road and bridge works for state road authorities

3.17.1.2 Eskom standards

- 240- 56364535 Architectural technical specification for structures and other buildings

- 240- 56364545 Structural design and engineering standard
- 240- 56364542 Standard for reinforced concrete foundations and structures
- 240 -85549846 Standard for design of drainage and sewerage infrastructure
- Eskom Road Specification Manual (240-84418186).

3.17.2 Control and Instrumentation

- IEC 61724 Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
- SANS 61850-7 Communication networks and systems for power utility automation - Part 7-420: Basic communication structure – Distributed energy resources logical nodes
- IEC 60870 Tele control equipment and systems. Remote control of photovoltaic power plants.
- IEC 62381 – Factory Acceptance test (FAT), Site Acceptance test (SAT), and Site Integration Test (SIT)
- IEC 62382 - Electrical and Instrumentation loop check activities
- IEC 62337 – Commissioning of electrical, instrumentation & control systems
- EIA/TIA 568 – Standard for structured cabling
- EIA/TIA 569 – Standard for communication pathways and spaces
- EIA/TIA 607 – Standard for grounding and bonding of communication cabling
- TIA/EIA 485 - Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
- SANS 10142-1 – The Wiring of Premises Part 1: Low-voltage installations
- SANS 10340-1 Installation of telecommunication cables Part 1: Fibre optic cables in buildings
- SANS 10340-2 Installation of telecommunication cables Part 2: Outdoor fibre optic cables
- SANS 60794-1-1 – Optical fibre cables - Part 1-1: Generic specification – General
- SANS 60794-1-2 – Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures
- SANS 61312 – Protection against lightning electromagnetic impulse
- SABS 1411: Parts 2-6 – Materials of Insulated Electric Cables and Flexible Cords
- SANS 60947-7-1 and SANS 60947-7-2 – The terminal blocks for the junction box terminations
- SANS 60529 – Degree of Protection provided by enclosures (IP)
- 240-56227443 Requirements for Control and Power Cables for Power Stations Standard, Sections 3.2.7, 3.6, 3.7, 3.8.7, 8, Tables 16, 17, 18 & 19;
- 240-56355754 Field Instrument Installation Standard, Section 3
- 240-56355815 - Field Instrument Installation Standard Junction Boxes and Cable Termination
- 240-56355541 Control System Computer Equipment Habitat Requirements Guideline
- 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard
- 240-56355808 Ergonomic Design of Power Station Control Suite Guideline
- 240-56355728 Human Machine Interface Design Requirements Standard.
- 32-894 Eskom Server Rooms and Data Systems Standard
- 240-55410927 Cyber Security Standard for Operational Technology
- 240-55863502 Definition of operational technology (OT) and OT IT collaboration accountabilities
- 240-79669677 DMZ Designs for OT Systems
- 240-56355466 Alarm Management System Guideline
- 240-56227443 Requirements for Control and Power Cables for Power Stations Standard

3.17.3 Electrical

All equipment and services supplied comply with the codes and standards listed below.

3.17.3.1 General:

- SANS 10142-1 – The wiring of Premises – Part 1: Low voltage installation.
- Grid Connection Code for Renewable Power Plants (RPPs) Connected to the Electricity
- Transmission system (TS) or the Distribution System (DS) in South Africa.
- 240-61268576: Standard for the Interconnection of Embedded Generation
- NRS 048 – Electricity Supply - Quality of Supply

3.17.3.2 PV Modules

- IEC 61215-1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 1: Test Requirements.
- IEC 61215-1-1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules.
- IEC 61215-1-2 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 1-2: Special requirements for testing of thin-film cadmium telluride (CDTE) based Photovoltaic (PV) modules.
- IEC 61215-1-3 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) Modules
- IEC 61215-1-4 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 1-4: Special requirements for testing of thin-film Cu(In,GA)(S,Se)2 based photovoltaic (PV) modules
- IEC 61215-2 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval -
- Part 2: Test procedures
- IEC 61730-1 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for Construction
- IEC 61730-2 - Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
- IEC 61701 - Photovoltaic (PV) modules - Salt mist corrosion testing
- IEC 62716 - Photovoltaic (PV) modules - Ammonia corrosion testing
- IEC 60891 - Photovoltaic devices - Procedures for temperature and irradiance corrections to
- measured I-V characteristics
- IEC 60904-1 - Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage Characteristics
- IEC 60904-2 - Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices
- IEC 60904-3 - Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic
- (PV) solar devices with reference spectral irradiance data
- IEC 60904-7 - Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for Measurements of photovoltaic devices
- IEC 60904-8 - Photovoltaic devices - Part 8: Measurement of spectral responsivity of a
- photovoltaic (PV) device
- IEC 60904-9 - Photovoltaic devices - Part 9: Classification of solar simulator characteristics
- IEC 60904-10 - Photovoltaic devices - Part 10: Methods of linear dependence and linearity measurements
- IEC 61829 - Photovoltaic (PV) array - On-site measurement of current-voltage characteristics
- IEC 61853 - Photovoltaic (PV) module performance testing and energy rating
- IEC 60068-2-78 - Environmental testing - Part 2-78: Tests - Test Cab: Damp heat steady state
- IEC 6134 - UV test for photovoltaic (PV) modules
- IEC 62548 - Photovoltaic (PV) arrays - Design requirements

3.17.3.3 Inverters

- IEC 62093 Ed. 1.0: Balance-of-system components for photovoltaic systems - Design qualification natural environments
- SANS 62109-1 Ed 1.0: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
- IEC 62109-2 Ed 2.0: Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
- IEC 62116 Ed 2.0: Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures.
- SANS 60730-1: Automatic electrical controls - Part 1: General requirements.
- IEC 61683: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- SANS 61000 – 6 – 2, 3 and 4: Electromagnetic compatibility (EMC)
- IEC 61727 Ed.2: Photovoltaic (PV) systems - Characteristics of the utility interface
- Grid connection code for Renewable Power Plants (RPPs) connected to the electricity Transmission system (TS) or the Distribution system (DS) in South Africa Version 2.6.
- IEC 60364-7-712 Electrical Installations of Buildings: Requirements for Special Installations or Locations – Solar Photovoltaic power supply systems
- IEC 62103 Electronic equipment for use in power installations

3.17.3.4 Electrical Cabling

- Requirements for cables for use in photovoltaic systems 2Pfg1169” by TÜV
- SANS 1507 Part 1: General - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- SANS 1507 Part 2: Wiring Cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- SANS 1507 Part 3: PVC Distribution cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- SANS 1507 Part 4: XLPE Distribution cables – Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3300 V)
- SANS 1507 Part 5: Halogen-free Distribution Cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- SANS 1507 Part 6: Service cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- SANS 10198 Parts 1-14 The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 1 to 14
- SANS 1213 Mechanical Cable Glands
- NRS 074- Part1 and Part 2 Low Voltage cables systems
- 240-56227443: Requirements for control and power cables for power stations standard

3.17.3.5 Earthing, Lighting and Surge Protection

- IEC 60364-4-41 Low-voltage plants installation. Part 4-41 - Protection for safety – protection against shock
- SANS 10313 – Protection against lightning
- SANS 62305 – Earthing and Lightning Protection
- SANS 10292 - Earthing of low-voltage (LV) distribution systems
- SANS 1063 - Earth rods and coupling
- SANS 10199 The design and installation of earth electrodes
- IEEE 80 Earthing – Ground System Design

- IEEE 665 - Guide for Generating Station Grounding
- SANS 61312-3 - Protection against lightning electromagnetic impulse Part 3: Requirements of surge protective devices (SPDs)
- SANS 62305-1 to 4 - Protection against lightning - Parts 1 to 4
- SANS 10313 - Protection against lightning - Physical damage to structures and life hazard
- SANS 10200 – Neutral earthing medium voltage industrial power systems
- NRS 039 Part 1 and Part 2 - Surge arresters for use in distribution systems
- IEC 61009 Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's)
- SANS 61024 – Protection of structures against lightning

3.17.3.6 Metering and Measurements

- 240-56227589: List of approved electronic devices to be used on Eskom Power station standard
- IEC 62053 Electricity metering equipment (A.C.) – particular requirements
- IEC 61036 Alternating current static watt-hour meters for active energy
- NRS 057/ SANS 474 Code of practice for electricity metering
- 240-56364444, Standard minimum requirements for the metering of electrical energy and demand
- SANS 61869-3/ IEC 61869-3 Instrument transformers Part 3: Additional requirements for inductive voltage transformers
- SANS 61869-2/IEC 61869-2 Instrument transformers Part 2: Additional requirements for current transformers

3.17.3.7 Performance Monitoring

- IEC 61724, Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
- IEC 61683, Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- IEC 60364-6 Ed. 1: Low Voltage Electrical installations.
- IEC 62446 "Grid connected photovoltaic systems – Minimum requirements for System documentation, commissioning tests & Inspections"
- ISO 9845-1, Solar energy - Reference solar spectral irradiance at the ground at different receiving conditions, Part 1: Direct normal and hemispherical solar irradiance for air mass 1.5.
- ISO 9847, Solar energy - Calibration of field pyranometers by comparison to a reference pyranometer. / BS 7621:1993 Method for calibrating field pyranometers by comparison to a reference pyranometer
- ISO 9060, Solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.
- ISO/TR 9901, Solar energy - Field pyranometers – Recommended practice for use.
- IEC 61725, Analytical expression for daily solar profiles

3.17.3.8 Transformers

- SANS 60076 -1 to12: Power transformers
- SANS 780 – Distribution transformers

3.17.3.9 Switchgear

- SANS 60269 Low-Voltage fuses Part 1 and Part 2
- SANS 1765 Low-voltage switchgear and controlgear assemblies (distribution boards) with a rated short-circuit withstand strength up to and including 10 kA

- SANS 60439-1 to 5 Low-voltage switchgear and controlgear assemblies pars 1 to 5
- SANS 60529 Specification for degrees of protection provided by enclosures (IP code)
- SANS1874: Switchgear- Metal-enclosed ring main units for rate AC voltage above 1kV and up to and including 36kV
- IEC 60255-1 Measuring relays and protection equipment part 1: common requirements
- 240-53114248: Thyristor and Switch mode chargers, AC/DC and DC/AC and UPS standard

3.17.3.10 Lighting and Small Power

- SANS 164: Plug and socket-outlet systems for household and similar purposes for use in South
- Africa
- SANS 890: Ballasts for fluorescent lamps
- SANS 1041: Tubular fluorescent lamps for general service
- SANS 1088: Luminaire entries and spigots
- SANS 10142-1: The wiring of premises Part 1: Low-voltage installations
- SANS 10114-1: Interior lighting Part 1: Artificial lighting of interiors
- SANS 10114-2: Interior lighting Part 2: Emergency lighting
- SANS 1266: Ballasts for discharge lamps (excluding tubular fluorescent lamps)

3.17.4 Safety Act

- Occupational Health and Safety Act 85 of 1993
- ISO 18001 – Occupational Health and Safety Management Systems

3.17.5 Environmental Protection

- IEC 60721-3-1 - Classification of groups of environmental parameters and their severities; Storage.
- IEC 60721-3-2 - Classification of groups of environmental parameters and their severities; Transportation.
- IEC 60721 -3-3 - Classification of groups of environmental parameters and their severities; Stationary use at weather protected locations.
- SANS 12944 – Corrosion Protection of Steel Structures
- SANS 14713 - Protection against corrosion of iron and steel structures – Zinc and aluminium coatings – Guidelines.
- ISO 14000 – Environmental Management Systems.

3.17.6 Fire Detection and Safety

- SANS 246: Code of Practice for the Fire Protection for Electronic Equipment Installations.
- NFPA 850: Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations.
- SANS 10400-T: South African National Standard Part T: Fire Protection
- SANS 10139 – Fire detection and alarm systems for buildings - System design, installation and servicing
- International Fire Code: Chapter 1 (Scope and Administration), Chapter 2 (Definitions), Chapter 3 (General Requirements), Chapter 4 (Emergency Planning and Preparedness), Chapter 5 (Fire Service Features), Chapter 6 (Building Services and Systems), Chapter 7 (Fire Resistance Rated Construction) and Chapter 9 (Fire Protection Systems)

3.17.7 Heating Ventilation and Air Conditioning (HVAC) System

- SANS 10400: The Application of the National Building Regulations
- SANS 10103: The measurement and rating of environmental noise with respect to annoyance and to speech communication
- SANS 10140-3: Identification colour marking Part 3: Contents of pipelines
- SANS 10142-1: The wiring of premises Part 1: Low-voltage installations
- SANS 10147: Refrigerating systems including plants associated with air-conditioning systems
- SANS 10173: The installation, testing, and balancing of air-conditioning duct work
- SANS 193: Fire dampers
- SANS 1238: Air-conditioning ductwork
- SANS 1287-1: Ventilation brattices and ducting Part 1: Flexible ducting
- SANS 1287-2: Ventilation brattices and ducting Part 2: Brattices, unsupported
- SANS 1424: Filters for use in air-conditioning and general ventilation
- ASHRAE 15: Safety Codes for mechanical refrigeration
- ASHRAE 62: American Society of Heating Refrigeration and Air Conditioning Engineers. Ventilation for acceptable indoor air quality
- ASHRAE 55: Thermal environmental condition for human occupancy
- ASHRAE 52/76: Standard test method for filters
- ASHRAE G1: Guideline for commissioning of air conditioning system

3.17.8 Fire Protection System

- SANS 246: Code of Practice for Fire Protection for Electrical Equipment Installations
- SANS 10400: The Application of the National Building Regulations
- SANS 1186: Symbolic safety signs
- SANS 1910: Portable refillable fire extinguishers
- SANS 1464: Safety of luminaires Part 22: Luminaires for emergency lighting
- SANS 10105: The use and control of fire-fighting equipment
- SANS 10139: Fire detection and alarm systems for buildings - System design, installation and servicing
- SANS 10177: Fire testing of materials, components and elements used in building
- 240-54937450: Fire Protection & Life Safety Design Standard
- 240-56737448: Fire Detection and Life Safety Design Standard

3.17.9 Water supply and reticulation

- SANS 62: Pipes suitable for threading and of nominal size not exceeding 150mm
- SANS 719: Electric welded low carbon steel pipes for aqueous fluids (large bore)
- SANS 776: Copper alloy gate valves
- SANS 1056-3: Ball Valves
- SANS 1123: Pipe Flanges
- SANS 241: Drinking water
- SANS 10400-A: The application of the National Building Regulations Part A: General principles and requirements
- SANS 10400-S: The application of the National Building Regulations Part S: Facilities for persons with disabilities
- SANS 10400-XA: The application of the National Building Regulations Part X: Environmental sustainability Part XA: Energy usage in buildings
- SANS 10252: Water supply and drainage for buildings

3.17.10 Sewerage and waste disposal

- SANS 10400-P:2010 Ed3 – The application of the National Building Regulations Part P: Drainage

4. RISK REGISTER

See Appendix E

5. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Dr Titus Mathe	GM - Generation Engineering
Prof Saneshan Govender	GM - Master Specialist
Dr Gary de Klerk	Senior Manager – Asset Management Mechanical (Acting)
Dr Oelof de Meyer	Asset Management Renewables
Miranda Skaka	Asset Management Renewables
Viren Heera	Asset Management Renewables
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Dheneshree Lalla	Asset Management - Chemical
Prudence Madiba	Asset Management - Control & Instrumentation
Machiel Viljoen	Asset Management - Electrical
Phera Rakeketsi	Asset Management - Electrical
Marlize Andre	Asset Management - Low Pressure Services
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Koogendran Govender	Chief Engineer – Peaking Asset Management
Reggie Chippe	Peaking Client Office
Lehlohonolo Tinte	Peaking Operational Support
Deon Van der Merwe	Peaking Operational Support
Kuben Naicker	Maintenance Manager-Renewables Business Unit
Zahier Kapery	Chief Engineer – Peaking Asset Management Civil

6. REVISIONS

Date	Rev.	Compiler	Remarks
August 2021	0.1	M Mtshali	First draft for Comments review Process
September 2021	0.2	M Mtshali	Final Draft after Comments Review Process
September 2021	1	M Mtshali	Final Document for Authorisation and Publication

7. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Miranda Skaka
- Oelof de Meyer
- Viren Heera
- Zahier Kapery

8. ACKNOWLEDGEMENTS

- Waleed Moses

APPENDIX A: TMY DATA

[Files attached]

APPENDIX B: SITE LAYOUT

[Files attached]

APPENDIX C: ELECTRICAL SLD

[Files attached]

APPENDIX D: EXISTING O&M BUILDINGS

[Files attached]

APPENDIX E: RISK REGISTER

The following risks are highlighted to enable further discussions with the Project Manager and other affected stakeholders.

No.	Risk Identified	Impact	Level	Proposed Mitigation
1.	• The project has imposed time constraints on engineering and design activities. • Engineering has conducted high level concept designs and has not performed a thorough global technology assessment, sensitivity analysis on plant performance, or provided optimised solutions.	• Higher uncertainty on PV plant capacity installation, energy yield estimations and plant performance. • Associated auxiliary power and water requirements not well defined. • Without the sensitivity analysis on PV plant performance and design optimisation, the following parameters have a high uncertainty: energy yield estimation, losses, capacity factor, performance ratio, amount of expected energy curtailment.	High	• The project's concept design should be sufficient to provide input to the functional specification. • A more detailed design will completed by the EPC contractor.
2.	• Basic Environmental Assessment findings might require that the location of the plant as per the conceptual site layout be relocated.	• This may result in changes to the design of the plant and hence trigger an engineering change process. • Point of connection may change and this will increase the costs of underground cabling or require overhead power lines.	Medium	• The exact location of the plant will be determined by the EPC contractor.
3.	• Water scarcity in the area may result in water not being available for operation of the plant	• Increased cost. • Technology options for panel cleaning will be limited. • Frequency of panel cleaning will be impacted.	Medium	• Proposed EPC cost benefit analysis.

		• Plant performance will be impacted		
4.	• Installation of a PV plant within a coastal area	• Corrosion of materials. • Salt deposits on panels. • Increase in O&M costs.	High	• Proposed EPC cost benefit analysis.
5.	• Utilisation of existing O&M building	• Expansion of the Sere Wind Farm staff complement will limit the space available for the solar PV staff. • Server room might not have sufficient space to accommodate the PV plant.	Low	• EPC contractor to design for expansion.
6.	• No access to information on the electricity supply to the neighbouring mine.	• Overhead lines could run through Site A. • Preferred solar PV location might have to change.	High	• Eskom to engage with the mine project team to obtain proposed layout.
7.	• Falling blades	• Damage to the PV plant by the falling blades. • Possible impact on insurance premiums for the site.	Low	• EPC contractor to finalise the solar PV plant layout according to the wind turbine location

8.	• High wind speeds	• The high wind speeds at the Sere site could impact on the PV mounting structure and foundation requirements, affecting the feasibility of the project.	High	• EPC contractor design to cater for the uptake caused by high wind speeds.
9.	• Generation output of wind turbines is high during a period of solar generation	• Higher curtailment on PV generation output. • Plant performance negatively affected. • Increase in the solar PV LCoE.	Low	• Sensitivity analysis should be done on the cost benefit. • Application to increase 105.8 MW site generation output.
10.	• Insufficient data from the existing Sere Wind Farm Geotechnical report	• Impact on selecting correct mounting structures and foundation options.	Low	• EPC contractor will conduct a geotech study for the solar PV mounting structure and foundations.

REPORT ON THE GEOTECHNICAL FOUNDATION INVESTIGATION FOR THE PROPOSED SERE WIND ENERGY FACILITY AT KOEKENAAP, WESTERN CAPE PROVINCE

REPORT NO. I08/942

Revision 00

Volume 1

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TITLE	**:**	**REPORT ON THE GEOTECHNICAL FOUNDATION INVESTIGATION FOR THE PROPOSED SERE WIND ENERGY AT KOEKENAAP, WESTERN CAPE PROVINCE**
Project Team	**:**	*BKS Palace Consortium*
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For BKS Palace Consortium

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SERE WIND ENERGY FACILITY

DETAILED GEOTECHNICAL FOUNDATION INVESTIGATION REPORT

APPENDICES

SERE WIND ENERGY FACILITY

DETAILED GEOTECHNICAL FOUNDATION INVESTIGATION REPORT

1. TERMS OF REFERENCE

In the last few years Eskom has been actively responding to the pressure to meet the electricity generating capacity for the nation in a number of ways. Besides increasing generating capacity through the use of conventional energy sources, Eskom has also embarked on a process to contribute clean renewable wind and solar energy to the National Transmission Grid. The Sere Wind Energy facility has been identified as one of the wind energy projects

In July 2010 the BKS Palace Consortium was appointed to carry out the detailed geotechnical investigations for the Sere Wind Energy Facility Scheme through Task Order No. 08, Panel B, signed on the 7th July 2010.

This final report deals with the information and data obtained from the geotechnical foundation investigation for the turbines, substation and related infrastructure. The report details the nature and properties of the surface and subsurface soils and rocks as well as the groundwater. This information is required for the design of the earthworks and the foundations for the proposed Sere Wind Energy Facility Phase 1 Project.

Following on from the feasibility level studies and the detailed geotechnical evaluation, the main components of the scheme are expected to be as follows:-:

- **Wind Turbine Units.** Originally fifty unit positions were to be investigated but this was reduced to fourty six units, at the request of the Client. It is anticipated that each unit will consist of an 80m to 110m high concrete tower supporting a swiveling generator nacelle weighing 60 tons. The blade diameter will be 100m.

- **Concrete Foundations.** If conventional pad footings are to be utilized, the pad foundations are expected to be between 20m x 20m or 15m x 15m depending on the supplier, to support each tower.

- **Substation.** The substation area is expected to be 80m x 80m which will receive generated power via underground distribution cabling from each wind turbine.

- **Workshop/Office Building and Visitors Centre** is expected to be located at the facility entrance.

- **Internal Access Roads** providing access to each wind turbine site, with a permanent travel surface of approximately 6m in width.

- **132kV Overhead Powerline** from the wind farm substation to the national power grid at Juno substation.

A separate final report has been submitted detailing the geotechnical investigations carried out at prospective borrow areas (BKS Report Reference I08/941, November 2010).

2. EXISTING INFORMATION

This report has been compiled predominantly form information obtained from the various investigations that have been undertaken since July 2010. Work previously undertaken at the site was utilized to optimize the current investigation. Previous reports relating to the site are listed below:

- Draft Report on the Geotechnical Investigation for the proposed Sere Wind Energy Facility-Borrow Areas for Construction Material.
  BKS Report Number J01386/171 of September 2010

- Report to Eskom, on an Eskom Wind Preliminary Geotechnical Evaluation.
  Black and Veatch Project 148645, File 41.0403, Rev 0. April 2008.

- Report to Eskom, on a Construction & Operation Environmental Management Plan (EMP) for the Wind Energy facility Project: Principles of Environmental Management Supported by Site Specific Guidelines. By Savannah Environmental (Pty) Ltd. submitted as part of the final EIA Report. February 2008.

- Report to Eskom, on a Geomorphological Assessment of the Proposed Wind Energy Facility and Associated Infrastructure on the West Coast (Matzikama Local Municipality and Western Cape Municipal Area 1) PM Illgner for Savannah Environmental (Pty) Ltd. January 2008.

- Report to Eskom, on a Heritage Impact Assessment (prepared as part of an EIA) of a Proposed Wind Energy Facility to be Situated at Olifants River Settlement 617, 620 and Grave Water Kop 158/5 situated on the Namaqualand Coast in the Vredendal District, South Western Cape, Tim Hart for Savannah Environmental (Pty) Ltd. December 2007.

- Report to Eskom, on a Specialist Impact Assessment for Proposed Eskom Wind Energy Facility on the Cape West Coast: Terrestrial Vegetation Component, Rev 2.
  Nick Helme Botanical Surveys for Savannah Environmental (Pty) Ltd. December 2007.

3. SITE DESCRIPTION

The 25 km^2 site is located on portions of the farms Olifants River Settlement 617 and 620, and Gravewaterkop 158 portion 5 situated on the Namaqualand Coast in the Vredendal District, about 14km west of Koekenaap in the north of the Western Cape Province . The locality of the site is indicated in Figure 1, Appendix A.

The area is remote and has been used mostly as a stock grazing area by local farmers, with sheep being the main livestock while the coastline has been subjected to diamond mining.

There are two main vegetation types present on the site, and where they meet a highly complex mosaic of both may be found. Namaqualand Strandveld occupies the coastal parts of the site and represents an extremely widespread vegetation type along the west coast. Namaqualand Sand Fynbos is found in the interior and lower parts of the site on a series of stabilised dunes.

Due to the numerous environmentally and archeologically sensitive regions within the study area, the investigations and borrow areas identified have been positioned in such a manner that minimum impact is experienced by these regions. The locations of the sensitive regions are indicated in Drawing Number J01386–004–117–01–R-00, Appendix B.

4. GEOLOGY

4.1 Regional Geology

According to the published 1:250 000 geological map, Sheet 3118 Calvinia, the area is underlain by deposits laid down in the Cenozoic Era, as indicated in Figure 2, Appendix A.

The Cenozoic Era began approximately 65 million years ago and has continued to the present day. During the Cenozoic Era there was significant continental uplift and erosion accompanied by fluctuations in the sea level. These events led to marine erosion and sedimentation with the sediments being, generally, comprised of fluvial and marine gravels, calcrete, silcrete and sand. Some of these deposits are still being laid down today along rivers and beaches. The published explanation of the published geological sheet (*De Beer, C.H., Gresse, P.G., Theron, J.N. and Almond, J.E. (2002), The Geology of the Calvinia Area, Explanation: Sheet 3118 Calvinia, 1:250 000 scale, The Council for Geoscience, Geological Survey of South Africa*) presents two sections showing the typical profiles to be found close to the Sere Wind Farm Facility. The first profile is present at a site north of Die Toring which is close to the site whilst the second profile is present at a site approximately 700m north of the Olifants River Mouth. The general profile at these two sites is presented below.

TABLE 4.1: GENERALISED STRATIGRAPHY

PROFILE IN THE CLIFFTOP NORTH OF DIE TORING (refer Figure A, below)
Red Aeolian sand
Heavy mineral dune sand with roots, burrows and whale bone fragments
Calcrete
Heavy mineral sand, dune and beach environment with shells, roots and burrows
Marine sand and gravel with well rounded small pebbles and cross beds
Bedrock with fluvial channels into which white clay, sand and angular quartz has been deposited

PROFILE 700M NORTH OF THE OLIFANTS RIVER MOUTH (refer Figure B, below)
Red calcareous soil
Calcrete
Marine (beach) sand and gravel beds
Calcrete
Clay beds
Fluvial channels
Marine sand and gravel with calcrete clasts
Fluvial sand and clay
Bedrock

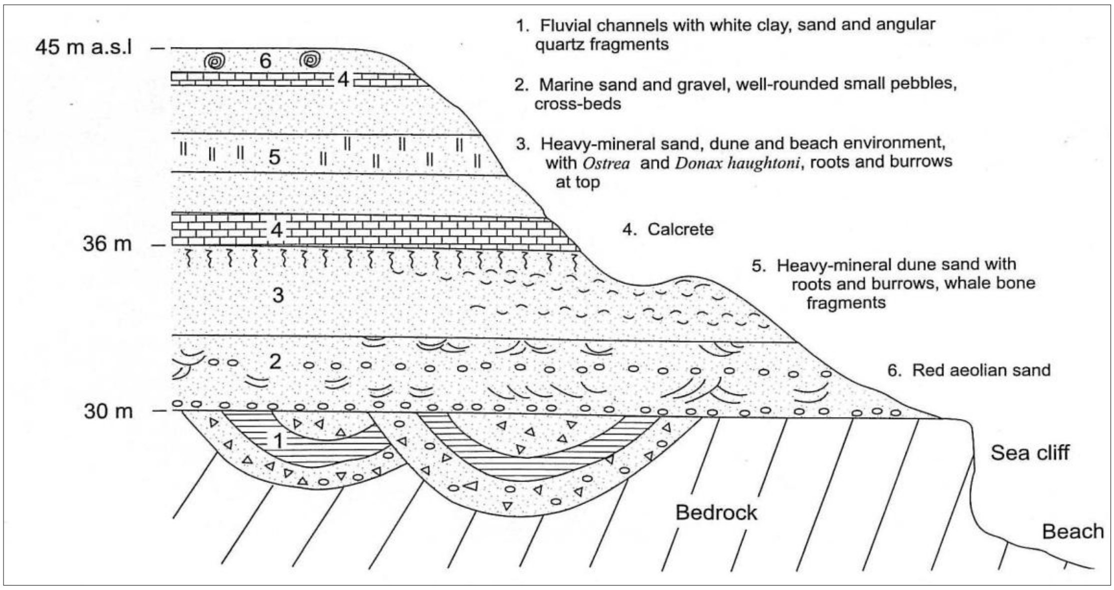

Figure A – Section through the Cenozoic deposits on the cliff north of Die Toring

(Ref: Explanation: Sheet 3118 CALVINIA, 1 : 250 000 scale. Council for Geoscience)

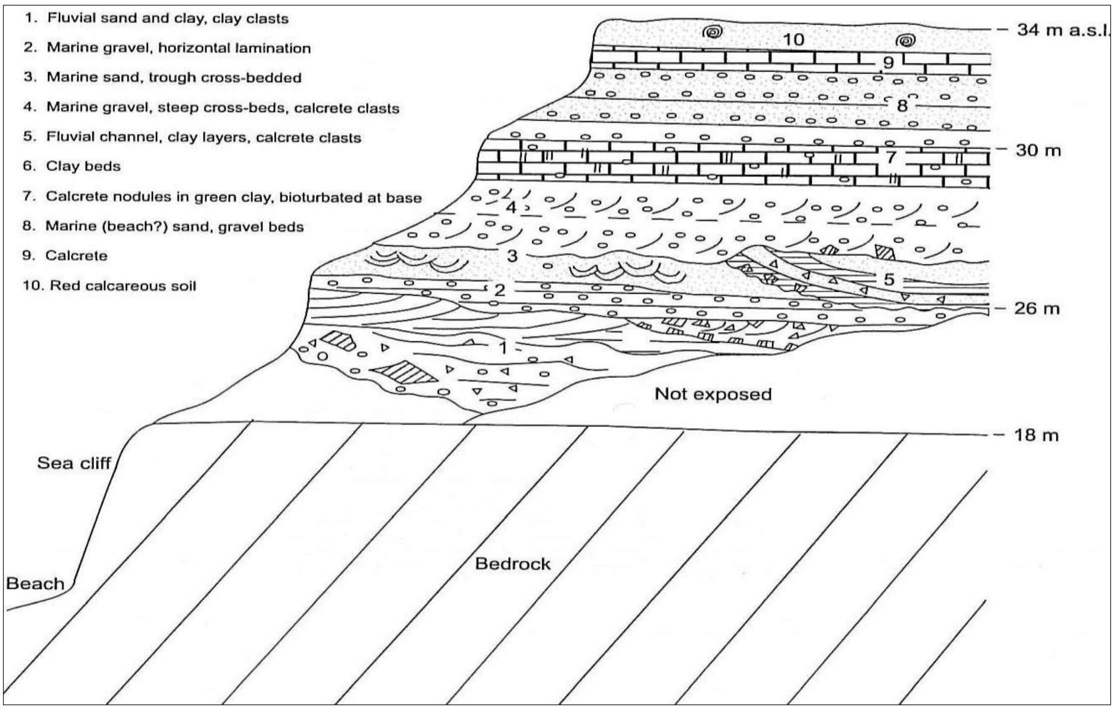

Figure B – Section through the Cenozoic deposits on the cliff 700m north of the Olifants River mouth

(Ref: Explanation: Sheet 3118 CALVINIA, 1 : 250 000 scale. Council for Geoscience)

It can be seen that the profile can vary considerably from location to location but basically comprises Aeolian (wind-blown) sands with a distinctive red colour indicative of the arid conditions in which the sand was deposited. This is underlain by marine and dune sands and gravels overlying bedrock. The aeolian, marine and dune sands have undergone varying degrees of pedogenesis and cementation with calcrete being present as discreet nodules or as much harder layers.

Based on the two sections showing the typical profiles (Figures A and B above), it was interpreted that both the aeolian and the dune sands have the same transporting agent, which is wind. The aeolian sand was however, blown from the coastal sands inland by the predominant wind direction. The dune sand on the other hand is very close to the sea and contains a significant amount of fragmented shells as well as some gravelly and gritty layers.

The bedrock comprises phylite, limestone and sandstone of the Gariep Supergroup.

4.2 Project Geology

In general, the profile at the Sere Wind Farm Facility was interpreted as follows:-

TABLE 4.2: STRATIGRAPHY AT THE SERE WIND FACILITY

Aeolian Deposits of the Cenozoic Era Pale red and orange, very loose to loose, sand. No gravel
Marine Deposits of the Cenozoic Era Lighter coloured, brown and beige, sand, silt, gravel and boulders. Significantly denser than the aeolian deposits above.
Bedrock Phylite, sandstone and quartzitic sandstone of the Gariep Supergroup.

In some areas the Cenozoic deposits are absent and sandstone and phylite of the Gariep Supergroup present themselves at surface as outcrops. However in general the bedrock occurs at depths of between 14m (Borehole WTG 28) and at a depth greater than 102m (for example in WTG 39, 41 and 43). This marked variation in depth to bedrock could be due to the presence of in-filled fluvial channels such as those present in the typical profile found north of Die Toring, as explained by the Council of Geoscience.

The thickness of the Cenozoic deposits, therefore, varies greatly across the site and generalizations are not valid.

The anticipated regional and project geology as shown in Figure 2, Appendix A, indicates that significant calcrete layers occur along the eastern boundary of the site. These outcrops were however not encountered during the site investigations. This is attributed to the fact that the original mapping was carried out on a macro scale (probably from aerial photography) and therefore at best may only be indicative, especially with the significant Aeolian deposits which cover the site.

Some calcrete layers, and indications of calcretisation have been encountered at depth in some of the boreholes and test pits across the site. The cemented materials that were encountered at the wind turbine positions are summarized below:

TABLE 4.3: SUMMARY OF CEMENTED LAYERS ENCOUNTERED

Wind Turbine Position	Drill Type	Depth (m)	Thickness (m)	Description
WTG 1	Rotary core	0.76 - 1.37	0.61	Cemented sand
		1.37 - 1.60	0.23	Very weakly cemented sand
		3.54 - 4.80	1.26	Minor ferricrete nodules
		34.71 - 34.81	0.10	Very weakly cemented sand
		35.15 - 36.21	1.06	Very weakly cemented sand
WTG 2	Rotary core	5.60 - 20.73	15.13	Minor ferricrete nodules
		33.79 - 35.39	1.60	Very weakly cemented sand
WTG 2	Percussion	4.00 – 18.00	14.0	Minor ferricrete nodules
		18.00 – 19.00	1.00	Ferruginised sand
WTG 4	Rotary core	0.70 - 1.64	0.94	Very weakly cemented sand
		2.02 - 3.34	1.32	Cemented sand
		4.22 - 6.47	2.25	Weakly cemented sand

		26.46 - 26.81 37.04 - 37.17	0.35 0.13	Abundant ferricrete nodules Very weakly cemented sand
WTG 6	Rotary core	3.44 - 5.00 15.66 - 15.78 15.78 - 23.34	1.56 0.12 7.56	Very weakly cemented sand Abundant ferricrete nodules Minor ferricrete nodules
WTG 6	Percussion	15.00 – 23.00	8.00	Ferruginised sand
WTG 8	Rotary core	4.61 - 5.73 5.73 - 14.39	1.12 8.66	Cemented sand Very weakly to weakly cemented sand
WTG 10	Rotary core	3.72 - 5.52	1.80	Very weakly to weakly cemented sand
WTG 12	Rotary core	21.80 - 23.28	1.48	Very weakly cemented sand
WTG 16	Rotary core	12.04 - 13.66	1.62	Very weakly to weakly cemented sand
WTG 19	Rotary core	2.44 - 2.64 12.77 - 12.86 13.44 - 13.75 15.96 - 16.11	0.20 0.09 0.31 0.15	Weakly cemented sand Weakly cemented sand Weakly cemented sand Very weakly cemented sand
WTG 20	Percussion	26.00 – 27.00	1.00	Very weakly cemented sand
WTG 21	Rotary core	0.75 - 0.90 1.20 - 1.48	0.15 0.28	Very weakly cemented sand Very weakly cemented sand
WTG 23	Rotary core	1.32 - 1.73	0.41	Very weakly cemented sand
WTG 26	Rotary core	0.76 - 1.50 1.50 - 2.13 26.16 - 35.85	0.74 0.63 9.69	Ferricrete nodules Minor ferricrete nodules Layers of cemented sand and silt layers
WTG 32	Rotary core	16.90 28.17 28.24 30.51	<0.05 <0.05 <0.05 <0.05	Layers of cemented sand (thickness was not recorded during logging(assumed to be less than 0.05m))
WTG 34	Rotary core	10.11 - 10.12	0.01	Weakly cemented sand
WTG 39	Percussion	2.00 - 4.00	2.00	Cemented sand
WTG 40	Rotary core	0.86 - 1.72 12.03 - 12.45	0.86 0.42	Weakly cemented sand Cemented sand
WTG 42	Rotary core	0.85 - 2.70 8.00 - 8.25 10.83 - 10.90	1.85 0.25 0.07	Cemented to strongly cemented sand Strongly cemented sand Strongly cemented sand
WTG 43	Percussion	2.00 – 10.00	8.00	Traces of weakly cemented

		10.00 – 15.00	5.00	sand Ferricrete nodules
WTG 44	Rotary core	1.10 - 2.27	1.17	Weakly cemented sand
WTG 46	Rotary core	16.10 - 16.17 16.30 - 16.40 16.70 - 16.80	0.07 0.10 0.10	Cemented sand Cemented sand Cemented sand
WTG 50	Rotary core	33.91 - 35.14	1.23	Cemented sand
WTG 51	Rotary core	0.77 - 1.31 1.31 - 1.62	0.54 0.31	Cemented sand Very weakly cemented sand
WTG 52	Rotary core	1.91 - 3.10 3.10 - 6.26 6.26 - 6.87 7.93 - 9.14 9.14 - 9.27 9.65 – 9.80 10.24 - 11.11 11.11 - 12.52 12.52 - 12.89	1.19 3.16 0.61 1.21 0.13 0.15 0.87 1.41 0.37	Very weakly cemented sand Weakly cemented to cemented sand Very weakly to weakly cemented sand Weakly cemented to cemented sand Very weakly cemented sand Very weakly cemented sand Very weakly cemented sand Weakly cemented to cemented sand Cemented sand
WTG 53	Rotary core	7.36 - 11.22 11.22 - 11.49 11.49 - 12.36 13.30 - 15.39 17.13 - 17.36 20.07 - 20.20	3.86 0.27 0.87 2.09 0.23 0.13	Very weakly to weakly cemented sand Cemented sand Weakly cemented sand Weakly cemented sand Very weakly cemented sand Very weakly cemented sand
WTG 54	Rotary core	2.63 - 2.73 2.95 - 5.09	0.10 2.14	Weakly cemented Weakly cemented
Substation				
Sub-Stn C	Rotary core	23.83 - 23.93	0.10	Hard ferricrete layer

It can be seen from the table above that most of the cemented layers are very weakly to weakly cemented with some having minor traces of ferricrete nodules. The cemented to strongly cemented layers were encountered at WTG 1, WTG 4, WTG 6, WTG 8, WTG26, WTG 32, WTG 39, WTG 40, WTG 42, WTG 46, WTG 50, WTG 51, WTG 52, WTG 53 and at substation C. The thickness of the cemented layers range from 0.02m in WTG 26 to 2.0m in WTG 39, with an average thickness of 0.5m.

Occasional cobbles and boulders were encountered at depth in some of the boreholes across the site. The cobbles and boulders that were encountered at the wind turbine positions are summarized below:

TABLE 4.4: SUMMARY OF COBBLES AND BOULDERS ENCOUNTERED

Wind Turbine Position	Drill Type	Depth (m)	Thickness (m)	Description
WTG 6	Percussion	29.00 – 30.00	1.00	Quartz boulder
WTG 6	Rotary core	29.41 - 29.88	0.47	Quartz boulder
WTG 10	Percussion	5.00 - 7.00	2.00	Possible cobble or boulder
WTG 12	Rotary core	54.37 - 54.51	0.14	Quartz cobble
WTG 16	Rotary core	42.29 - 42.65 43.52 - 46.68	0.36 3.16	Quartzitic sandstone boulder Quartzitic sandstone boulder
WTG 23	Rotary core	48.08 - 48.71	0.63	Sandstone boulder
WTG 36	Rotary core	8.22 - 8.28 8.75 - 9.36 24.10 - 24.20	0.06 0.61 0.10	Sandstone cobble Sandstone boulder Sandstone cobble
WTG 50	Rotary core	19.75 - 21.32 22.77 - 25.28	1.57 2.51	Sandstone boulder Sandstone boulder

It can be seen from the table above that the occurrence of the cobbles and boulders generally occurs at depths greater than 20m. The only locations where cobbles and boulders were found at depths less than 20m were at WTG 10, WTG 36 and WTG 50.

5. METHOD OF INVESTIGATION

The current investigation was tailored to obtain information with regards to founding conditions at the proposed Wind Turbine Generator (WTG) locations and the substation area. The turbines are presently arranged in three distinct lines as indicated in Table 5.1 below:

TABLE 5.1: TURBINE POSITIONS

Turbine Line	Number of Turbines	Approximate Line Length (km)	Turbine Positions
Line 1 (Southern Line)	16	7.560	WTG1, 2, 4, 6, 8, 10, 12, 14, 16, WTG18 – WTG24
Line 2 (Middle Line)	14	6.600	WTG25 – WTG38
Line 3 (Northern Line)	12	5.000	WTG 39 – WTG50
Line 1 (Additional Holes)	4	-	WTG 51 – WTG 54

Drawing Number J01386–004–117–02–R-00, Appendix B, indicates the three distinct lines along which the wind turbines are located as well as the positions of the individual wind turbines. The co-ordinates for the wind turbine positions are indicated on Drawing Number J01386–004–117–03–R-00, Appendix B.

The geotechnical field investigations commenced in July 2010 and were completed in October 2010. The geotechnical field investigations comprised the following:

- Percussion drilling (at locations alternating with rotary core boreholes),
- Rotary core drilling (at locations alternating with percussion drilled boreholes),
- Dynamic Probe Super Heavy (DPSH) testing,
- Plate load testing,
- Excavation of test pits
- Geophysical surveys comprising electrical resistivity survey and seismic refraction surveys

In addition, the following investigations were also carried out:

- Laboratory testing
- Seismic hazard assessment
- Assessment of the dynamic response of the soil

5.1 Percussion Drilled Boreholes

Percussion boreholes were drilled at selected wind turbine positions along the three turbine lines and at the corner positions of the substation area to confirm the stratigraphy to depth. The percussion drilling was carried out by JKay Developments under the supervision of BKS (Pty) Ltd during the period 20th July 2010 to the 3rd August 2010. Percussion drilling was carried out at alternate wind turbine positions, as indicated in Table 5.2 below:

TABLE 5.2: PERCUSSION DRILLED BOREHOLE POSITIONS

Structure	Borehole Number	Total Depth Drilled (m)
Line 1 (Southern Line)	WTG 2	40
	WTG 6	40
	WTG 10	54
	WTG 14	54
	WTG 18	24
	WTG 20	27
	WTG 22	18
	WTG 24	18
Line 2 (Middle Line)	WTG 25	54
	WTG 27	54
	WTG 29	54
	WTG 31	54
	WTG 33	47
	WTG 35	40
	WTG 37	40
Line 3 (Northern Line)	WTG 39	102
	WTG 40	40
	WTG 41	102
	WTG 42	40
	WTG 43	102
	WTG 44	40
	WTG 45	84
	WTG 46	40
	WTG 47	57
	WTG 49	40
Substation	A	20
	B	20
	C	20
	D	20

During percussion drilling disturbed samples of the material being penetrated are recovered; such as dust and fines of the softer materials and small chips of the harder materials. This information is supplemented by the recording of various drilling parameters such as penetration time, air loss whilst drilling and sample recovery.

Samples were recovered at 1.0m intervals during percussion drilling. These samples were logged on site by an Engineering Geologist according to current standards and practice (Brink and Bruin, 2002).

5.2 Rotary Core Boreholes

Rotary cored boreholes were generally drilled at locations alternating with percussion drilled boreholes. However, selected rotary core boreholes were drilled at the same location where a percussion hole had been drilled to confirm the sub-soil profile and consistency. The rotary core boreholes were drilled to provide information on the stratigraphy to depth and to obtain undisturbed samples for subsequent testing. Standard Penetration Tests (SPT) were generally carried out at 3.0m intervals within the borehole to determine the in-situ consistency of materials at depth.

TABLE 5.3: Rotary Cored Borehole Positions

Structure	Borehole Number	Total Depth Drilled (m)
Line 1 (Southern Line)	WTG 1	37.77
	WTG 2	39.83
	WTG 4	39.99
	WTG 6	39.90
	WTG 8	56.07
	WTG 10	61.60
	WTG 12	99.25
	WTG 16	50.10
	WTG 19	43.36
Line 1 (Southern Line)	WTG 21	50.41
	WTG 22	50.03
	WTG 23	50.08
	WTG 24	49.57
Line 2 (Middle Line)	WTG 26	50.82
	WTG 28	18.35
	WTG 30	37.68
	WTG 32	38.21
	WTG 34	49.92
	WTG 36	49.53
	WTG 38	50.04
Line 3 (Northern Line)	WTG 40	50.29
	WTG 42	49.94
	WTG 44	48.37
	WTG 46	50.17
	WTG 48	50.00
	WTG 50	40.77
Line 1 (Additional Holes)	WTG 51	39.81
	WTG 52	40.53
	WTG 53	40.72
	WTG 54	40.15
Substation	A	24.99
	C	25.04

From the above table it can be seen that four additional holes were drilled along Line 1. These holes were drilled to investigate a possible relocation of the wind turbines along Line 1.

The boreholes were drilled by the main contractor, RW Enterprises under the supervision of BKS (Pty) during the period 20th July 2010 to October 2010.

The rotary cored borehole core was logged and photographed on site by an Engineering Geologist according to current standards and practice (Brink and Bruin, 2002). The legend and descriptive terms utilized for soil and rock in this report are included in Appendix C. The core is at present stored in a purpose built shed on the site.

5.3 Dynamic Probe Super Heavy (DPSH)

Dynamic Probe Super Heavy (DPSH) testing was undertaken in order to ascertain the consistency of the underlying soils at each proposed wind turbine position and at the substation. These were carried out by Geopractica under the supervision of BKS (Pty) Ltd from 20th July 2010 through to the 3rd August 2010. The depth to refusal at each test location is indicated in the table below:

TABLE 5.4: POSITIONS OF DPSH TESTS

Structure	Borehole Number	Depth to Refusal (m)
Line 1 (Southern Line)	WTG 1	0.9
	WTG 2	8.1
	WTG 4	2.1
	WTG 6	3.6
	WTG 8	4.5
	WTG 10	4.5
	WTG 12	5.7
	WTG 14	3.9
	WTG 16	2.4
	WTG 18	2.7
	WTG 19	3.3
	WTG 20	2.7
	WTG 21	8.1
	WTG 22	12.6
	WTG 23	10.8
	WTG 24	11.7
Line 2 (Middle Line)	WTG 25	0.9
	WTG 26	1.2
	WTG 27	0.6
	WTG 28	3.3
	WTG 29	9.6
	WTG 30	0.9
	WTG 31	2.6
	WTG 32	4.8
	WTG 33	3.6
	WTG 34	3.0
Line 2 (Middle Line)	WTG 35	7.5
	WTG 36	4.2
	WTG 37	3.3
	WTG 38	1.5
Line 3 (Northern Line)	WTG 39	0.9
	WTG 40	6.6
	WTG 41	5.4
	WTG 42	0.9

TABLE 5.4: POSITIONS OF DPSH TESTS

Structure	Borehole Number	Depth to Refusal (m)
	WTG 43	1.8
	WTG 44	3.3
	WTG 45	1.8
	WTG 46	8.0
	WTG 47	4.0
	WTG 48	5.5
	WTG 49	5.1
	WTG 50	4.0
Substation	A	4.5
	B	3.0
	C	3.0
	D	4.5

From the above table, the range of values for depth of refusal may be summarized as follows:

TABLE 5.5: RANGE OF VALUES FOR DEPTH OF DPSH REFUSAL

Location	Minimum Depth to Refusal (m)	Average Depth to Refusal (m)	Maximum Depth to Refusal (m)
Line 1 (Southern)	0.9	5.5	12.6
Line 2 (Middle)	0.6	3.4	9.6
Line 3 (Northern)	0.9	3.9	8.0
Substation	3.0	3.8	4.5

From the above table it can be seen that there is no obvious correlation between the various lines or location on site.

5.4 Plate Load Tests

Plate load testing was carried out at selected turbine positions in order to obtain load/settlement curves to determine the elastic (subgrade) modulus in the vertical and horizontal directions. The tests were undertaken by Geopractica under the supervision of BKS (Pty) Ltd from 20th July 2010 through to the 5th August 2010.

Plate load tests were carried out in the weakly cemented marine deposits which underlie the loose Aeolian sands. It is anticipated that the wind turbine structures will be founded in the marine deposits and that the overlying loose Aeolian sands will be stripped to spoil.

For the vertical tests, the soils were subjected to maximum stresses of either 943kPa or 531kPa utilizing 600mm and 450mm diameter plates respectively. For the horizontal tests, the soils were subjected to a maximum stress of 912kPa utilizing a 300mm diameter plate. The locations where plate load tests were carried out are indicated in Table 5.5 below:

TABLE 5.6: LOCATION OF PLATE LOAD TESTS

Wind Turbine Line	Borehole Number	Depth (m) Vertical	Depth (m) Horizontal
Line 1 (Southern Line)	WTG 4	2.1	2.5
	WTG 16	3.1	3.5
Line 2 (Middle Line)	WTG 26	1.0	1.5
	WTG 34	2.3	No test due to wall collapse
Line 3 (Northern Line)	WTG 41	1.3	1.5
	WTG 46	1.3	1.7

5.5 Excavation of Test Pits

Test pits were excavated with a tracked excavator at the locations where plate load tests were carried out. Test pits allowed the profiling and sampling of the upper layers of a profile. Representative samples (undisturbed and/or disturbed) were obtained for subsequent laboratory testing. The presence of water and depth of refusal for each pit was noted and a visual assessment made of the stability of the sidewalls.

Each test pit was profiled and photographed by an Engineering Geologist according to current South African standards and procedures (Brink and Bruin 2002). The legend and descriptive terms utilized for soil and rock in this report are included in Appendix C. All test pits were labeled with the prefix "T" such as TWTG34, i.e. test pit excavated at Wind Turbine Position WTG34.

5.6 Laboratory Testing

Both disturbed and undisturbed soil samples were submitted for laboratory testing. The laboratory testing was carried out by Soillab in Bellville, Cape Town and comprised the following:-

- Determination of Indicator properties including grading and Atterberg Limits
- Determination of shear strength properties.
- Determination of Collapse Potential

Chemical Tests (pH, sulphates, chlorides and resistivity) were only carried out on samples from the potential borrow pit areas, but the results will be reported on in this report.

5.7 Seismic Refraction and Electrical Resistivity

Geophysical surveys were carried out on site by Engineering and Exploration Geophysical Services from 26th July 2010 through to September 2010.

The objective of the geophysical survey was to measure in-situ physical properties, namely P-wave velocity, S-wave velocity and electrical resistivity, at the potential turbine sites. Estimates of shear wave velocity were required to a depth of 50m. To achieve this it was necessary to conduct multiple MASW surveys at each site with different source and receiver geometries, and with the application of an additional technique, refraction micro-tremor (ReMI). Seismic refraction data gathered at the same time as the shear wave measurements and ERI data provides images of near surface and deeper changes in rock properties, as well as near-surface resistance measurements for electrical grounding calculations.

MASW, ReMi, seismic refraction and ERI data were collected at each of the potential turbine sites. MASW and ReMi spreads were deployed such that the centre of the receiver array coincided with boreholes or as close as could be practically achieved, however, it was found that survey orientations had to be altered sometimes to enable the best compromise in terms of acquiring data of the greatest possible quality so that, for example, full advantage was taken of background energy sources (e.g. ocean swell) suitable for the ReMi survey technique. Resistivity lines were also collected along the three rows of turbine sites.

The three data-sets (MASW/ReMi, seismic refraction and ERI) usually exhibit a high degree of correlation between each other and to the lithology. Exceptions to this appear in the refraction data; in some instances the pressure wave velocity does not vary in a fashion as would be predicted from the MASW/ReMi data, instead being faster than expected perhaps because of moisture within the overburden matrix.

Whilst a degree of caution should be taken when using p-wave refraction velocities, on the basis of the high degree of correlation between different geophysical techniques as demonstrated by the data synthesis sections, a high degree of confidence can be assumed when using the derived physical properties for further geotechnical engineering and design.

5.8 Probabilistic Seismic Hazard Analysis

The probabilistic seismic hazard analysis was undertaken by the Council for Geoscience (CGS) in Pretoria.

The scope of work carried out by the CGS, included the following elements:

- Review of local / regional geological and seismological information within 300km of the site;
- Preparation of a regional seismotectonic model on the basis of the earthquake catalogue defined above, as well as geological information regarding the tectonic structures of the area.
- Ground motion assessment in terms of PGA and UHS for a return period of 475 years.

- Deaggregation of spectral accelerations (Sa(0.5), Sa(1.0), Sa(2.0) and Sa(3.0)).

The seismic hazard assessment was performed based on a very simple geological model. This assessment considered the contributions of natural seismicity to the groundshaking hazard, using a simplified seismotectonic model based on existing seismological data. The calculations were carried out within a probabilistic framework, and included consideration of uncertainties associated with the inputs. These uncertainties were treated using a logic-tree methodology.

CGS provided ground motion parameters required for the seismic design of the wind farm. These included Peak Ground Acceleration (PGA) values, uniform hazard spectrum (UHS) for 10% probability of exceedance in 50 years (475 year return period, or 1: 475 annual frequency of exceedance) and deaggregation. No specific building code was provided to guide the work, but guidelines for a normal multi-story building were adopted.

5.9 Dynamic Response of the Soil Assessment

The dynamic response of the soil assessment was undertaken by the Council for Geoscience (CGS) in Pretoria.

The procedure for investigating the dynamic response of the soil to strong ground motion consisted of the following steps:

- Typical soil profiles (soil models) are compiled to represent the range of ground conditions encountered at the site. Each profile is defined in terms of the soil material types encountered and the variation of shear wave velocity versus depth.
- Dynamical soil properties are assigned to the geological profile.
- Scaled time histories are then generated based on recorded ground motions at bedrock. Bedrock response spectra, representative of seismic hazard level at site are used to define appropriate earthquake strong-motion records for input as reference bedrock ground motions.
- Amplification factors are determined for each soil profile using two methods. One dimensional site response analysis is carried out using the program Shake.
- Surface response spectra are obtained for a range of periods using two methods.

Local site conditions play an important role in earthquake-resistant design and must be accounted for on a case-by-case basis. A significant part of damage observed in destructive earthquakes around the world is associated with seismic wave amplification due to local site effects. The local site conditions could be very different due to variations in thickness and properties of soil layers and could have significant effects on the characteristics of earthquake ground motions on the ground surface. The soil amplification factors are directly related to the shear-wave velocity profiles, modulus degradation and damping ratio of the soil. Site response analysis is therefore a fundamental part of assessing the seismic hazard.

6. EVALUATION OF INVESTIGATION RESULTS

6.1 Percussion Borehole Results

The percussion borehole logs are presented in Appendix D and the observed stratigraphy is summarised in Table 6.1 below.

The wind turbine positions are located on aeolian sands which range from 1m to in excess of 50m in thickness and which are underlain by marine deposits consisting of silt, sand, clay, gravel and occasionally rock. Various levels of pedogenesis are evident within these deposits. The variability in the profiles is due to the depositional environment as discussed in Section 4, Geology, of this report.

Calcrete was encountered at various depths within some of the boreholes with the layers of calcrete varying in thickness from 1m to 17m.

The water table was encountered at depths of 72m, 69m and 79m in Boreholes WTG 39, 41 and 43 respectively.

The percussion boreholes drilled at the substation (A, B, C and D) were terminated at a depth of 20m. The full depth profile consisted of aeolian sands with some occasional ferruginisation being evident. No water was encountered in the boreholes drilled at the substation.

TABLE 6.1: STRATIGRAPHY OBSERVED AT PERCUSSION HOLES

BOREHOLES	THICKNESS OF LAYERS (m)						
	AEOLIAN	MARINE				ROCK	
	Sand	Sand	Sandy Silt Silty Sand	Clayey Sand	Clayey Silt Silt	Depth	Rock
WTG 2	0.0 - 12	12.0 - 40.0					
WTG 6	0.0 - 29.0	30.0 - 40				29.0 - 30.0	Quartzite Cobble
WTG 10	0.0 - 5.0	5.0 - 7.0 48.0 - 53.0			7.0 - 48.0 53.0 - 54.0 [1]		
WTG 14	0.0 - 54.0						
WTG 18	0.0 - 24.0						
WTG 20	0.0 - 26.0	26.0 - 27.0					
WTG 22	0.0 -18.0						
WTG 24	0.0 - 1.0	1.0 - 18.0					
WTG 25	0.0 - 3.0	3.0 - 5.0	5.0 - 54.0				
WTG 27	0.0 - 3.0		32.0 - 54.0		3.0 - 32.0		
WTG 29	0.0 - 13.0	16.0 -28	13.0 - 16.0			28.0 - 54.0	Quartzite
WTG 31	0.0 - 17.0	17.0 -18.0	22.0 - 38.0		18.0 - 22.0	38.0 - 54.0	Quartzite
WTG 33	0.0 - 47.0						
WTG 35	0.0 - 40.0						
WTG 37	0.0 - 5.0				5.0 - 40.0		
WTG 39	0.0 - 29.0	29.0 - 31.0	31.0 - 102.0 [1]				
WTG 40	0.0 - 13.0		13.0 - 32.0		32.0 - 40.0 [1]		
WTG 41	0. 0 - 18.0	18.0 - 30.0				30.0 - 102.0	Quartzite
WTG 42	0.0 - 7.0	8.0 - 11.0 16.0 - 17.0 25.0 - 38.0	7.0 - 8.0 11.0 - 16.0 17.0 - 25.0 38.0 - 40.0				
WTG 43	0.0 - 10.0	10.0 - 64.0 74.0 - 102 [1]			64.0 - 74.0 [1]		
WTG 44	0.0 - 2.0	10.0 - 40.0		2.0 - 10.0			
WTG 45	0.0 - 6.0	22.0 - 42.0 80.0 - 84.0	12.0 - 22.0 42.0 - 80.0	6.0 - 12.0			
WTG 46	0.0 - 1.0	16.0 - 17.0	17.0 - 18.0 29.0 - 40.0	1.0 - 16.0	18.0 - 29.0		
WTG 47	0.0 - 26.0		26.0 - 38.0		38.0 - 57.0		
WTG 49	0.0 - 18.0	18.0 - 24.0 [2]				24.0 - 40.0	Quartzite
A	0 . 0 - 20.0						
B	0 . 0 - 20.0						
C	0 . 0 - 20.0						
D	0 . 0 - 20.0						

[1] Residual Phyllite

6.2 Rotary Cored Borehole Results

The rotary cored borehole logs and accompanying core photography are presented in Appendix E and the observed stratigraphy is summarised in Table 6.2 below.

Based on the rotary cored borehole profiles, the wind turbines positions are underlain by aeolian sands ranging from 0 to 44m in thickness, these in turn are underlain by marine deposits consisting of silt, sand, clay, gravel and occasionally rock. Various levels of pedogenesis are evident within these deposits. The substation is underlain by aeolian sands present from surface to a depth of at least 25m.

The variability in the profiles is due to the depositional environment as discussed in Section 4, Geology, of this report.

The water table was not encountered during the rotary drilling.

Utilizing the information from the rotary core and percussion boreholes, geotechnical long-sections were developed along the three wind turbine lines. These long sections are indicated on Drawing Numbers J01386–004–117–04–R-00, J01386–004–117–05–R-00 and J01386–004–117–06–R-00 in Appendix B.

TABLE 6.2: STRATIGRAPHY OBSERVED AT ROTARY CORE BOREHOLES

BOREHOLES	THICKNESS OF LAYERS (m)									
	AEOLIAN	MARINE							ROCK	
	Sand	Sand	Silty Sand/Sandy Silt	Clayey Sand clS Sandy Clay sCl	Clayey Silt clSi Silty Clay siCl	Clay	Boulders and Cobbles Layers		Depth	Description
							Depth	Description		
WTG 1	0.00 - 11.10	11.10 - 37.77								
WTG 2	0.00 - 10.82	10.82 - 39.83								
WTG 4	0.00 - 5.40	5.40 - 39.99								
WTG 6	0.00 - 26.86	26.86 - 29.41	29.88 - 36.17		36.17 - 39.90 **clSi		29.41 - 29.88	Quarzite Cobble		
WTG 8	0.00 - 5.73	5.73 - 14.07* WC 18.57 - 20.07	14.07 - 14.39 38.07 - 40.30 41.45 -42.35 42.50 - 42.82 ** 42.88 - 43.90 ** 44.86 - 55.96 **	14.39 - 14.56 clS 24.81 - 25.02 clS 42.82 - 42.88 ** clS-CM 43.90 - 44.86 ** clS	14.56 - 18.57 clSi 20.07 - 24.81 clSi 25.02 - 38.07 clSi 40.30 - 41.45 clSi 42.35 - 42.50 clSi				50.15 - 50.52	VSR-Phyllite
WTG 10	0.00 - 4.29	4.29 - 5.52 VWC-WC 42.51 - 43.70 ³	33.92 - 35.12 39.22 - 42.51 43.70 - 49.00 49.14 - 50.30 50.71 - 57.17 58.04 - 61.60**		5.52 - 33.92 35.12 - 39.22 clSi 49.00 - 49.14 clSi 50.30 - 50.71 clSi 57.17 - 58.04** clS					
WTG 12	0.00 - 20.50	21.80 - 23.28 VWC 80.04 - 81.54 **	20.50 - 21.80 23.28 - 27.99 30.04 - 30.14 30.50 - 30.54 32.34 - 33.53 33.88 - 36.22 38.02 - 38.92 40.19 - 41.04 41.10 - 54.37 54.51 - 62.04 ** 64.23 - 66.68 ** 66.82 - 70.90 ** 75.54 - 77.04 ** 79.71 - 80.04 ** 93.42 - 97.70 **		27.99 - 30.04 Si 30.14 - 30.50 Si 30.54 - 32.34 Si 33.53 - 33.88 Si 36.22 - 38.02 Si 38.92 - 40.19 Si 62.04 - 64.23 ** clSi 66.68 - 66.82** clSi 70.90 - 75.54** clSi 77.04 - 79.71** clSi 81.54 - 93.42** clSi	41.04 - 41.10	54.37 - 54.51	Quartz cobble		

SR Soft Rock
MHR Medium hard rock
HR Hard rock
VHR Very Hard Rock
A AEOLIAN
M MARINE
Calcrete-Pedogenic
Cal -Calcareous

*Silcrete (Pedogenic Origin)
**RESIDUAL PHYLLITE
Phyllite with scattered hard subangular fine quartz gravel
¹Pedogenic origin, with occasional ferricrete
²Clayey silt with soft to medium hard quartzitic sandstone
³Quartz gravel

DEGREE OF CEMENTATION
VWC Very Weakly Cemented
WC Weakly Cemented
CM Cemented
SC Strongly Cemented

MATERIAL
S Sand
Si Silt
Cl Clay
G Gravel
C Cobbles
B Boulder
Q Quartz

TABLE 6.2: STRATIGRAPHY OBSERVED AT ROTARY CORE BOREHOLES

BOREHOLES	THICKNESS OF LAYERS (m)									
	AEOLIAN	MARINE							ROCK	
	Sand	Sand	Silty Sand/Sandy Silt	Clayey Sand clS Sandy Clay sCl	Clayey Silt clSi Silty Clay siCl	Clay	Boulders and Cobbles Layers		Depth	Description
							Depth	Description		
WTG 16	0.00 - 13.66		13.66 - 17.85 21.35 - 25.59 46.86 - 50.10		17.85 - 21.35 Si 25.59 - 42.29 clSi 42.65 - 43.52 clSi 44.15 - 46.86 [2] clSi		42.29 - 42.65 43.52 - 44.15	SR-MHR Quartzitic sandstone boulder SR-MHR Quartzitic sandstone boulder		
WTG 19	0.00 - 16.11	16.11 - 17.49 20.96 - 21.29 22.07 - 25.68 25.78 - 28.78 31.70 - 32.80 34.52 - 34.80	28.78 - 31.70 32.80 - 34.52	25.68 - 25.78 clS	17.49 - 20.96 Si 21.29 - 22.07 clSi				34.80 - 43.36	VSR-HR Sandstone
WTG 21	0.00 - 44.44	44.44 - 50.41								
WTG 22	0.00 - 44.03		44.03 - 50.03							
WTG 23	0.00 - 0.36 clS	1.32 - 21.84 44.32 - 45.58	23.22 - 42.80 45.58 - 48.08 48.71 - 50.08	0.36 - 1.32 clS 21.84 - 23.22 clS	42.80 - 44.32 clSi		48.08 - 48.71	Sandstone Boulder		
WTG 24	0.00 - 0.60	3.50 - 15.40 45.04 - 45.24 47.34 - 48.44	15.40 - 44.17 44.81 - 45.04	0.60 - 3.50 clS 45.24 - 47.34 sCl	44.17 - 44.81 clSi 48.44 - 49.57 clSi					
WTG 26	0.00 - 0.76	0.76 - 2.13	21.61 - 42.76	42.76 - 44.98 clS	2.13 - 21.61 clSi 44.98 - 45.44 ** clSi 46.52 -46.82 ** clSi				45.44 - 46.52 46.82 - 50.85	HR-Phyllite HR-Phyllite
WTG 28	0.00 - 3.11 clSi	3.11 - 4.99			4.99 - 14.33 clSi				14.33 - 18.35	SR-HR Quartzite
WTG 30	0.00 - 9.90	9.90 -11.70	11.70 - 33.59						33.59 - 37.68	HR-VHR Quartzite
WTG 32	0.00 - 21.76	21.76 - 27.85 28.50 - 30.30	30.52 - 35.02	27.85 - 28.50 30.30 - 30.52 clS					35.02 - 38.21	HR-Sandstone
WTG 34	0.00 - 31.81	31.81 - 48.81				48.81 - 49.92				
WTG 36	0.00 - 8.22	8.28 - 8.75 9.36 - 13.70 24.20 - 24.50 [3]	13.70 - 24.10 24.50 - 24.65 24.70 - 34.13 ** 34.50 - 35.23 **		35.37 - 35.47 Si 35.68 - 47.45 ** Si		8.22 - 8.28 8.75 - 9.36 24.10 - 24.20	Sandstone Boulder Sandstone Boulder Sandstone Boulder	24.65 - 24.70 34.13 - 34.50 35.23 - 35.37 35.47 - 35.68 47.45 - 49.53	SR-Phyllite HR-Phyllite HR-Phyllite HR-Phyllite HR-SR Phyllite

SR Soft Rock
MHR Medium hard rock
HR Hard rock
VHR Very Hard Rock
A AEOLIAN
M MARINE
Calcrete-Pedogenic
Cal -Calcareous

*Silcrete (Pedogenic Origin)
**RESIDUAL PHYLLITE
Phyllite with scattered hard subangular fine quartz gravel
[1]Pedogenic origin, with occasional ferricrete
[2]Clayey silt with soft to medium hard quartzitic sandstone
[3]Quartz gravel

DEGREE OF CEMENTATION
VWC Very Weakly Cemented
WC Weakly Cemented
CM Cemented
SC Strongly Cemented

MATERIAL
S Sand
Si Silt
Cl Clay
G Gravel
C Cobbles
B Boulder
Q Quartz

TABLE 6.2: STRATIGRAPHY OBSERVED AT ROTARY CORE BOREHOLES

BOREHOLES	THICKNESS OF LAYERS (m)									
	AEOLIAN	MARINE							ROCK	
	Sand	Sand	Silty Sand/Sandy Silt	Clayey Sand clS Sandy Clay sCl	Clayey Silt clSi Silty Clay siCl	Clay	Boulders and Cobbles Layers		Depth	Description
							Depth	Description		
WTG 38	0.00 - 1.42	20.78 - 20.86 ** ³	21.10 - 21.81 ** 30.42 - 31.92 **		3.00 - 3.60 ** Si 4.80 - 6.54 ** Si 7.04 - 8.04 ** Si 10.22 - 10.70 ** Si 18.28 - 20.78 ** Si 36.56 - 47.04 ** Si				1.42 - 3.00 3.60 - 4.80 6.40 - 7.04 8.04 - 10.22 10.70 - 18.28 20.86 - 21.10 21.81 - 30.42 31.92 - 36.56 47.04 - 50.04	HR-Phyllite HR-Phyllite SR-Phyllite SR-Phyllite SR-HR Phyllite SR-HR Phyllite SR-HR Phyllite SR-HR Phyllite SR-MHR Phyllite
WTG 40	0.00 - 12.45	43.50 - 43.55 ** ³	12.45 - 32.03 41.13 - 43.50 ** 44.38 - 46.36 ** 47.03 - 50.29 **	46.36 - 47.03 ** sCl	32.03 - 41.13 ** Si 43.55 - 44.38 ** Si					
WTG 42	0.00 - 6.80	8.00 - 11.10 16.06 - 16.99 24.47 - 37.49 43.92 - 49.94	6.80 - 8.00 11.10 - 16.06 16.99 - 24.47 37.49 - 43.92							
WTG 44	0.00 - 2.27	10.14 - 14.75 18.51 - 43.00 46.67 - 47.78** 48.00 - 48.37**	14.75 - 18.51	2.27 - 10.14					43.00 - 46.67	MHR-VHR-Sandstone
WTG 46	0.00 - 0.70	15.97 - 16.92	16.92 - 17.42 28.45 - 39.80 39.92 - 40.17	0.70 - 15.97 clS	17.42 - 28.45 Si 39.80 - 39.92 siCl 40.17 - 50.17					
WTG 48	0.00 - 12.75	26.85 - 29.00 29.70 - 32.00 35.20 - 49.64	29.00 - 29.70	12.75 - 26.85 clS 32.0 - 35.20 clS		49.64 - 50.0 **				
WTG 50	0.00 - 19.75	21.32 - 22.77 32.13 - 37.30 **	27.81 - 28.88		25.28 - 27.81 siCl 28.88 - 32.13 siCl		19.75 - 21.32 22.77 - 25.28	Sandstone Boulder Sandstone Boulder	37.30 - 40.77	VHR-Quartzite
WTG 51	0.00 - 0.77	0.77 - 39.81								
WTG 52	0.00 - 5.05	5.05 - 12.89	12.89 - 18.50 **		18.50 - 38.00 38.00 - 40.53 ** clSi					

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MHR Medium hard rock
HR Hard rock
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M MARINE
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¹Pedogenic origin, with occasional ferricrete
²Clayey silt with soft to medium hard quartzitic sandstone
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WC Weakly Cemented
CM Cemented
SC Strongly Cemented

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Si Silt
Cl Clay
G Gravel
C Cobbles
B Boulder
Q Quartz

TABLE 6.2: STRATIGRAPHY OBSERVED AT ROTARY CORE BOREHOLES

BOREHOLES	THICKNESS OF LAYERS (m)									
	AEOLIAN	MARINE							ROCK	
	Sand	Sand	Silty Sand/Sandy Silt	Clayey Sand clS Sandy Clay sCl	Clayey Silt clSi Silty Clay siCl	Clay	Boulders and Cobbles Layers		Depth	Description
							Depth	Description		
WTG 53	0.00 - 11.49	11.49 - 13.30	13.30 - 13.87 WC 14.66 - 26.44 30.76 - 30.96 31.87 - 34.26 36.54 - 40.72		13.87 - 14.66 WC-Si 26.44 - 30.76 Si 30.96 - 31.87 Si 34.26 - 36.54 Si					
WTG 54	0.00 - 2.73	2.95 - 5.09 WC	5.09 - 6.49 16.30 - 27.79	2.73 - 2.95 clS 33.57 - 38.12 ** clS	6.49 - 16.30 clSi 27.79 - 33.57** clSi 38.12 - 39.57 ** clSi				39.57 - 40.15	SR-PHYLLITE
A	0.00 – 25.00									
C	0.00 – 25.04									

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HR Hard rock
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Calcrete-Pedogenic
Cal -Calcareous

*Silcrete (Pedogenic Origin)
**RESIDUAL PHYLLITE
Phyllite with scattered hard subangular fine quartz gravel
[1]Pedogenic origin, with occasional ferricrete
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[3]Quartz gravel

DEGREE OF CEMENTATION
VWC Very Weakly Cemented
WC Weakly Cemented
CM Cemented
SC Strongly Cemented

MATERIAL
S Sand
Si Silt
Cl Clay
G Gravel
C Cobbles
B Boulder
Q Quartz

6.3 Results from Standard Penetration Tests (SPT)

From the SPT "N" values, the allowable bearing capacity for material at various depths can be determined. The allowable bearing capacity has been determined using the "Brink, Partridge and Williams, 1982" method which is based on permissible settlements of 25 mm derived from average N values below the footprint of the foundation for different founding depths.

Beneath the wind turbine positions, the SPT results indicate that the in-situ soils are typically loose to medium dense, consisting of unconsolidated sediments to approximately 10m depth. Thereafter the in-situ soil consistencies increase from dense to extremely dense with depth to 50m. For the substation, the SPT results indicate that the in-situ soils are typically medium dense to very dense from approximately 1.0m to 25m depth.

The estimated allowable bearing capacities on in-situ soil between 3.0m and 4.0m depth are summarised in Table 6.3 below. A conservative maximum of 500 kPa has been assumed. The different soil types have been taken into account when estimating the allowable bearing capacities, hence bearing capacities may differ where the "Blows per 300mm" are the same for different material types.

TABLE 6.3 : ALLOWABLE BEARING CAPACITY FROM SPT "N" VALUES

Structure	Borehole Position	Depth Below Surface (m)	Blows Per 300mm	Allowable Bearing Capacity (kPa)
Line 1 (Southern Line)	WTG 1	3.0 – 3.5	9	150
	WTG 2	3.0 – 3.5	20	250
	WTG 4	4.0	Refusal	500
	WTG 6	3.0 - 3.5	Refusal	500
	WTG 8	3.2 – 3.7	33	350
	WTG 10	3.0 – 3.4	Refusal	500
	WTG 12	3.4	29	300
	WTG 16	3.0 – 3.4	Refusal	500
	WTG 19	3.5 – 3.9	60	470
	WTG 21	3.5 – 3.9	28	300
	WTG 22	3.0 – 3.5	18	240
	WTG 23	3.2 – 3.7	21	260
	WTG 24	3.2 – 3.7	15	200
Line 2 (Middle Line)	WTG 26	3.0 – 3.5	35	250
	WTG 28	3.4 – 3.6	Refusal	500
	WTG 30	3.0 – 3.5	45	450
	WTG 32	3.0 – 3.5	23	280
	WTG 34	3.0 – 3.5	36	370
	WTG 36	3.4 – 3.8	24	300
	WTG 38	5.0	Refusal	300
Line 3 (Northern Line)	WTG 40	4.2	42	400
	WTG 42	4.0	Refusal	500
	WTG 44	4.0	60	500
	WTG 46	4.0	24	200
	WTG 48	3.0 – 3.5	46	450
	WTG 50	3.5 – 3.6	Refusal	500
Substation	A	3.3 – 3.7	35	350
	C	3.0 – 3.6	74	500
Line 1 (Additional positions)	WTG 51	3.0	19	250
	WTG 52	3.0	Refusal	500
	WTG53	3.0	42	400
	WTG 54	6.6	53	300

6.4 Results from Dynamic Probe Super Heavy (DPSH) Testing

The results from the DPSH tests are presented in Appendix F.

From the DPSH results the allowable bearing capacity for material at various depths can be determined. The allowable bearing capacities were determined using the "Brink, Partridge and Williams, 1982" method which is based on permissible settlements of 25 mm derived from average N values below the footprint of the foundation for different founding depths.

For the wind turbine positions, the DPSH results indicate that the overlying in-situ soils are generally loose to approximately 1.0m depth, thereafter increasing to medium dense to very dense to depths of 12.6m. Refusal depths were variable occurring between 0.9m to 12.6m across the site.

The DPSH results for the substation indicate that the in-situ soils are typically medium dense to dense sediments to approximately 2.5m depth, thereafter increasing to dense to very dense material with depth to 4.5m. Refusal depths varied slightly occurring at depths ranging between 3.0m and 4.5m across the substation footprint.

The estimated allowable bearing capacities on in-situ soil between 3.0m and 4.0m depth are summarised in Table 6.4 below. A conservative maximum of 500 kPa has been assumed. The different soil types have been taken into account when estimating the allowable bearing capacities, hence bearing capacities may differ where the "Blows per 300mm" are the same for different material types.

TABLE 6.4 : ALLOWABLE BEARING CAPACITIES FROM DPSH TESTS

Structure	Borehole Number	Depth Below Surface (m)	Blows Per 300mm	Allowable Bearing Capacity (kPa)
Line 1 (Southern Line)	WTG 1	0.9	Refusal	500
	WTG 2	3.0	25	300
	WTG 4	2.0	Refusal	500
	WTG 6	3.6	Refusal	500
	WTG 8	3.0	32	350
	WTG 10	3.0	34	350
	WTG 12	3.0	27	300
	WTG 14	3.0	58	470
	WTG 16	3.0	Refusal	500
	WTG 18	3.0	Refusal	500
Line 1 (Southern Line)	WTG 19	3.0	Refusal	500
	WTG 20	3.0	Refusal	500
	WTG 21	3.0	22	270
	WTG 22	3.0	22	270
	WTG 23	3.0	35	350
	WTG 24	3.0	29	300
Line 2 (Middle Line)	WTG 25	0.9	Refusal	500
	WTG 26	1.2	Refusal	500
	WTG 27	0.6	Refusal	500
	WTG 28	3.3	Refusal	500
Line 2 (Middle Line)	WTG 29	3.0	19	250
	WTG 30	0.9	Refusal	500
	WTG 31	2.6	Refusal	500
	WTG 32	3.0	44	430
	WTG 33	3.3	90	500
	WTG 34	3.0	Refusal	500
	WTG 35	3.0	21	200
	WTG 36	3.9	Refusal	500
	WTG 37	3.0	Refusal	500
	WTG 38	1.5	Refusal	500

TABLE 6.4 (cont) :

ALLOWABLE BEARING CAPACITIES FROM DPSH TESTS

Structure	Borehole Number	Depth Below Surface (m)	Blows Per 300mm	Allowable Bearing Capacity (kPa)
Line 3 (Northern Line)	WTG 39	0.9	Refusal	500
	WTG 40	3.0	44	400
	WTG 41	3.0	41	400
	WTG 42	0.9	Refusal	500
	WTG 43	1.8	Refusal	500
	WTG 44	3.3	Refusal	500
	WTG 45	1.8	Refusal	500
	WTG 46	3.0	35	350
	WTG 47	4.0	Refusal	500
	WTG 48	3.0	40	400
	WTG 49	3.0	15	200
	WTG 50	3.3	Refusal	500
Substation	A	3.0	24	200
	B	3.0	Refusal	500
	C	3.0	Refusal	500
	D	3.0	25	200

These values correlate well with the results from the SPT values obtained during the rotary core drilling.

6.5 Results from Plate Load Tests

The plate load test results are presented in Appendix G.

Plate load testing was carried out at selected turbine positions in order to obtain load/settlement curves to determine the elastic (subgrade) modulus in the vertical and horizontal directions. Plate load tests were carried out in the weakly cemented marine deposits which underlie the loose Aeolian sands. It is anticipated that the wind turbine structures will be founded in the marine deposits and that the overlying loose Aeolian sands will be stripped to spoil.

In assessing the results from the plate load tests, only the moduli determined from the second (reload) cycle are recorded in Table 6.5 as bedding effects are largely eliminated in the second cycle. The estimated Elastic Moduli of the upper marine deposits summarised in Table 6.4 below.

TABLE 6.5: ELASTIC MODULI FROM PLATE LOAD TEST RESULTS

Structure	Vertical Stiffness (MPa)			Horizontal Stiffness (MPa)		
	2nd cycle		Depth (m)	2nd cycle		Depth (m)
	E_{50}^{Secant}	$E_{50}^{Tangent}$		E_{50}^{Secant}	$E_{50}^{Tangent}$	
WTG4	848	959	2.1	250	257	2.5
WTG16	316	280	3.1	140	132	3.5
WTG26	110	192	1.0	132	156	1.5
WTG34	187	194	2.3	No horizontal test done (wall collapse)		-
WTG41	429	229	1.3	81	46	1.5
WTG46	285	280	1.3	65	72	1.7

6.6 Results from Test Pits

The test pit profiles are presented in Appendix H.

The test pits were excavated at the wind turbine positions where plate load testing was carried out. Based on the test pits, the site is underlain by dry to slightly moist pale red very loose to loose aeolian sand followed by slightly moist orange medium dense clayey SAND, marine origin. This is in turn underlain by slightly moist orange medium dense to dense very weakly to weakly cemented calcareous clayey sand which is pedogenic in origin. The exception is Wind Turbine 26, which is underlain by slightly moist grey firm to stiff intact clayey SILT which is considered to be pedogenic in origin.

No groundwater seepage was encountered in any of the test pits.

Due to the dry to slightly moist moisture content and loose granular nature of the upper layer(s), the sidewalls in the upper portion of the majority of the test pits were unstable.

The stratigraphy observed in the test pitws is summarized in Table 6.6 below:

TABLE 6.6: STATIGRAPHY OBSERVED IN THE TEST PITS

TEST PIT	THICKNESS OF LAYERS (m)							Depth of hole (m)
	AEOLIAN	MARINE				PEDOGENIC		
	Sand	Sand	Silty Sand	Clayey Sand clS Sandy Clay sCl	Clayey Silt clSi Silty Clay siCl	Depth	Material	
T WTG4	0.0 - 1.2			1.2 – 1.75 clS 1.75 - 2.2 clS WC 2.2 – 2.8 clS WC		2.2 - 2.7	Calcrete	5
T WTG16	0.0 - 1.5			2.7 - 2.8 clS WC 3.1 - 3.4 clS VWC* 3.4 - 4.6 clS 4.6 - 4.8 clS VWC* 4.8 - 5.0 clS				5
T WTG26	0.0 - 1.0				1.0 - 5.0 clSi*			5
T WTG34	0.0 - 2.2	2.2 - 2.4		2.4 - 4.5 clS				4.5
T WTG41	0.0 - 0.9		0.9 - 1.6 clsiS VWC*	1.6 - 5.0 CM Cal				5
T WTG46	0.0 - 0.9 siS		0.9 - 2.0 clsiS WC*	2.0 - 5.0 siclS WC Cal*				5

MATERIAL TYPE		***DEGREE OF CEMENTATION***	***ORIGIN***
S Sand	*C Cobbles*	*VWC Very Weakly Cemented*	** Pedogenic :*
Si Silt	*B Boulders*	*WC Weakly cemented*	
Cl Clay	*Cal Calcareous*	*CM Cemented*	
G Gravel	*Q Quartz*	*SC Strongly Cemented*	

6.7 Laboratory Test Results

The results from the laboratory testing on the soil samples are presented in Appendix K. The results from laboratory testing are summarized in the following tables:

The results from grading analysis are presented in Table 6.7.
The results from collapse potential and shear box tests are presented in Table 6.8.
The results from chemical tests carried out on selected samples from Borrow are A and B are presented in Tables 6.9 and 6.10 respectively.

Discussion of these results is presented after the summary tables.

TABLE 6.7: SUMMARY OF GRADING ANALYSES

Test Pit	Depth (m)	Soil Description	Atterberg Limits			Percentage Composition				Unified Soil Classification	Moisture Content (%)	Potential Expansive-ness
			Plasticity Index	Liquid Limit (%)	Linear Shrinkage (%)	Gravel	Sand	Silt	Clay			
TWTG16	1.5 - 5	Silty SAND	NP	0	0	0	87	3	10	SM	8.3	Low
TWTG26	2.6 - 5	SILT	10	34	5	0	3	51.3	45.8	ML	31.4	Low
TWTG34	2.2 - 2.4	Poorly graded SAND	NP	0	0	0	99	0.7	0.3	SP	0.7	Low
TWTG34	2.4 - 4.5	Silty, clayey SAND	4	21	2	0	84	2.3	13.7	SC-SM	6.5	Low
TWTG41	0.9 - 1.6	Silty, clayey SAND	6	27	3	0	73	20.5	6.6	SC-SM	11.4	Low
TWTG41	1.6 - 5	Silty SAND	NP	0	0	0	79	4.8	16.3	SM	8	Low
TWTG46	0.9 - 2	Silty SAND	24	56	12	0	57	26	17	SM	14.7	Medium
TWTG48	2.0 - 5	Silty SAND	NP	0	0	0	82	9	9	SM	8.9	Low
WTG16	3.1 - 3.5	Poorly graded SAND, with Silt	SP	0	0.5	0	88	3.2	8.8	SP-SM	6.5	Low
WTG46	1.1 - 1.5	Silty SAND	0	0	0	0	62	24.3	13.7	SM	15.3	Low

NP Non Plastic
SP Semi Plastic

TABLE 6.8: SUMMARY OF COLLAPSE POTENTIAL AND SHEAR BOX TESTS

Test Pit	Sample number	Depth (m)	Soil Description	Collapse Potential	Severity of Problem	Severity Classification (after ASTM D5333)	Dry Shear Box		Remoulded	
							Cohesion (kPa)	Friction Angle (°)	Cohesion (kPa)	Friction Angle (°)
TWTG 4	A	2.8	Silty coarse SAND, weakly cemented	0.0%	No Problem	None	131	44.1		
	B	2.8	Silty coarse SAND, weakly cemented	0.0%	No Problem	None				
	C	2.8	Silty coarse SAND, weakly cemented	0.1%	No Problem	Slight	157.9	46.7		
TWTG 16	-	2.4	Silty SAND	1.5%	Moderate Trouble	Slight	1.1	41.7		
	-	3.1 - 3.5	Silty SAND	0.0%	No Problem	None	9.4	42.6	1.1	35.3
TWTG 21	-	4.98 - 5.29	SAND	0.2%	No Problem	Slight				
TWTG 23	-	4.5 - 4.85	SAND	0.1%	No Problem	Slight				
TWTG 26	-	5.02 - 5.27	CLAY	0.0%	No Problem	None				
TWTG 28	-	6.34 - 6.53	SILT	0.0%	No Problem	None				
TWTG 34	-	2.0 - 2.3	Silty SAND	0.6%	No Problem	Slight	5.2	40.5	2.0	31.1
TWTG 46	A	1.5	Silty coarse SAND, weakly cemented	0.5%	No Problem	Slight			0.5	35.2

Table 6.9: SUMMARY OF CHEMICAL TEST RESULTS – BORROW AREA A

Test Pit / Sample ID	Depth (m)	Soil Description	PH	Conductivity (S/m)	Chloride content (mg/l)	Chloride content (%)	SO_4 (mg/l)	SO_4 (%)
B3	2.4 – 5.0	Silty SAND	7.5	0.18	530.43	0.053	130.51	0.013
B5	2.7 – 4.7	Silty SAND	6.97/6.86	0.25	378.88	0.038	143.34	0.014
B6	1.2 – 5.0	Silty SAND	6.67	0.30	519.86	0.052	117.76	0.12
C1	0.9 – 2.4				511.05	0.051	90.45	0.009
C6	2.0 – 4.6	Silty SAND	7.94	0.13	280.20	0.028	46.10	0.005
D3	3.0 – 4.3	Silty SAND	6.72 / 7.59	0.19	361.26	0.036	173.67	0.017
G3	0.9 – 2.1	Silty SAND	8.87	0.49	722.52	0.072	220.02	0.022
G5	1.9 – 5.0				348.93	0.035	177.54	0.018
G6	2.7 – 5.0	Silty SAND	8.24	0.53	907.57	0.091	744.88	0.074
G7	1.5 - 2.5	Silty SAND	7.33	0.23	572.73	0.057	158.03	0.016

pH ranges from 6.67 – 8.24, degree of aggressiveness of water is low to moderately aggressive

Conductivity (s/m) ranges from 0.13 – 0.53, which shows that the soils are very corrosive on site.

Chloride content (mg/l) ranges from 280.20 – 905.57, degree of aggressiveness of water is low to moderately aggressive

Sulphate content (mg/l) ranges from 46.1 – 744.88, degree of aggressiveness of water is low to moderately aggressive

Table 6.10: SUMMARY OF CHEMICAL TEST RESULTS – BORROW AREA A

Test Pit / Sample ID	Depth (m)	Soil Description	PH	Conductivity (S/m)	Chloride content (mg/l)	Chloride content (%)	SO_4 (mg/l)	SO_4 (%)
I1	4.2 – 5.0	Silty SAND	7.69	0.25	500.48	0.050	114.27	0.011
J3	1.5 – 4.7	Silty, clayey SAND	8.07	0.45	713.71	0.071	206.83	0.021
K3A	1.0 – 4.2	Clayey SAND	8.11 / 7.89	0.24	447.61	0.045	112.83	0.011
K3A	4.2 – 5.0	Silty, clayey SAND	6.99	0.26	451.14	0.045	145.43	0.015
M2	2.9 – 5.0	Sandy, lean Clay	7.4	0.50	942.80	0.094	148.16	0.015

pH ranges from 6.99 – 8.11 degree of aggressiveness of water is low to moderately aggressive

Conductivity (s/m) ranges from 0.24 – 0.50, which shows that the soils are very corrosive on site.

Chloride content (mg/l) ranges from 447.61 – 942.80 degree of aggressiveness of water is low to moderately aggressive

Sulphate content (mg/l) ranges from 112.83 – 206.83 degree of aggressiveness of water is low to moderately aggressive

a) Results from Grading Analyses

No grading analyses were carried out on the overlying loose Aeolian sands as these are expected to be excavated to spoil. Only the underlying marine deposits were submitted for laboratory testing. Based on the grading analyses, the soils in the Sere Wind Facility consist of 62% to 88% sand, 3.2% to 24.3% of silt and 8.8% to 13.7% clay, classifying the material as either SM, SP, SP - SM or SC – SM according to the Unified Soil Classification System. This means that the marine deposits to a depth of approximately 5.0m consist predominantly of poorly graded sand, gravelly sands with little or no fines, or silty sands, poorly graded sand silt mixtures. The results of the laboratory tests confirm that the soils are not plastic indicating that the soil is unlikely to be expansive.

b) Results from Compaction Tests

In the compacted state the sands have a Maximum Dry Density of 1835kg/m^3 to 1920kg/m^3 under 100% Modified AASHTO effort, at Optimum Moisture Contents of 9% to 12.8%. California Bearing Ratio tests revealed it to have a CBR value of between 14 and 22 at 95% Maximum Modified AASHTO density (extracted from the companion Borrow Pit Report for the Sere Wind Facility).

c) Results from Collapse Potential Tests

Undisturbed block samples of the sand were subjected to Collapse Potential tests The Collapse Potential was generally less than 1% indicating “no trouble” with collapse settlement. Although one sample, WTG16 at 2.4m had a Collapse Potential of 1.48% which just brings it into the “moderate trouble”.

d) Results from Shear Box Tests

Shear box testing was undertaken in order to determine the shear strength parameters of the material.

An initial set of tests were carried out on undisturbed dry samples in order to evaluate the shear strength parameters of the in-situ material. These tests produced peak angles of internal friction between 40.5˚ and 46.7˚ with cohesions between 1.1kPa and 157.9kPa. The higher values of cohesion are as a result of the cementing that has taken place in the soil sample.

A second set of tests were carried out on remoulded saturated samples in order to obtain relevant shear strength parameters for material that would be reworked on site. Tests on the remoulded samples produced peak angles of internal friction between 31.1˚ and 35.3˚ with cohesions between 0.5kPa and 2.0kPa.

e) Stable Side Slopes

Slopes in the cemented soils could have temporary slopes cut semi-vertical. Based on the angle of internal friction, soil slopes created with the remoulded material should have batters of between 1 (vertical) to 2 (horizontal) and 1 (vertical) to 1.5 (horizontal). However it must be noted that these recommendations are valid for temporary slopes only, and for those in the dry condition. Any seepage would warrant further investigation and perhaps flattening of the sidewalls.

f) Results from Chemical Testing

Selected samples of the near surface samples encountered at site (Borrow Areas A & B) were subjected to chemical analysis to test for pH, resistivity, soluble sulphates and soluble chlorides. assumption has been made that other soils found across the site may be more, less or of a similar corrosive nature.

g) Corrosivity of Soils

Selected samples from Borrow Area A and B were subjected to chemical test analysis for the purpose of corrosion assessment. The samples were tested for pH, resistivity, soluble sulphates and soluble chlorides. The range of chemical test results from both borrow areas are summarised below:

pH		**Conductivity (S/m)**		**Chlorides (mg/l)**		**Sulphates (mg/l)**	
Min	Max	Min	Max	Min	Max	Min	Max
6.67	8.87	0.13	0.53	280.20	942.80	46.10	744.88

According to the publication by the Concrete – Durability Bureau of the Portland Cement Institute *(Deterioration of Concrete in Aggressive Waters – Measuring aggressiveness and Taking Countermeasures, Table 3)*, a pH range of 6.67 – 8.87, a water soluble chloride content of 280.20 – 942.80 mg/l and a sulphate concentration of 46.10 – 744.88 mg/l are all considered moderately aggressive.

Resistivity/conductivity tests indicated that the soils range from 0.13 – 0.53 S/m, and this range is considered to be very corrosive to steel.

The corrosion test results above are indicative of potential soil corrosivity based on the tested samples. Due to the relative uniformity of the soils across the Sere Wind Facility, it is assumed that other soils across the site, including founding soils for the wind turbines may be of a similar corrosive nature.

6.8 Results from the Seismic Refraction Survey

The results of the seismic refraction and electrical resistivity analysis are contained within the report tiltled:

"Multi-Channel Analysis of Surface Waves, Seismic Refraction and Electrical Resistivity Imaging on Turbine Sites. Sere Wind Energy Facility, Lutzville, South Africa. Dated 02 November 2010"

This report is included as Appendix I and the major findings are summarised below.

Overall, data quality for the seismic techniques (MASW, ReMi and seismic refraction) was good although wind-generated noise resulted in some degradation during the refraction acquisition program. Repeats of the some of the survey lines were carried out to improve data quality. After successful completion of the affected site, first arrivals could be confidently picked for all shots.

Data quality for the ERI surveys was reasonable but due to significant heterogeneity both laterally and vertically, the section plots presented in the report appear patchy. Limitations of the inversion package used to process the data may have contributed to some of the artefacts present in the sections, however, in general the sections correlate with the results from the seismic survey, suggesting that most of the complexity observed in the ERI data can be attributed to genuine changes in ground resistivity. Additionally, the Wenner array used for the ERI surveys is optimally suited to resolve vertical variations in resistivity such as horizontal bedding, as was expected on the site, but is less capable in accurately mapping horizontal changes, for example vertical pillar like structures.

All shear wave data sets were mapped to a maximum depth of 50m, the proposed depth of investigation. For each row of the proposed wind turbine sites, cross-section data is displayed in the report in sections of approximately 1000 m to eliminate the need to apply disproportionate vertical exaggeration to the plots. These figures are presented with line distance along the upper X-axis and WGS84 Zone 34S Easting or Northing coordinates along the lower X-axis. The elevation (relative RL) is annotated on the Y-axis using elevations derived from Shuttle Radar Topography Mission (SRTM).

The data sets in the report are coloured as follows:

- Shear Velocity (Vs) is coloured in such that faster Vs are warmer colours (yellows through reds) and slower Vs are cooler colours.
- P-wave (Vp) velocity is coloured such that faster Vp are warmer colours (yellows through reds) and slower Vp are cooler colours.
- ERI data (resistivity) is coloured such that more resistive layers are warmer colours (yellows through reds) and areas of lower resistivity are cooler colours.

a) Results from Seismic Refraction

The seismic refraction data has demonstrated that harder, more competent lithologies such as sandstone and quartzite are likely to be present in the near surface (less than 20m). The existence of such units is, at some sites, confirmed by a sharp increase in shear wave velocity as derived from MASW / ReMi data. However, in some circumstances this correlation does not exist. The lack of correlation between the two techniques is attributed to differences in the way in which the techniques interact with the environment (for example saturated vs unsaturated ground) and its effect on the correlation between p-wave velocity from refraction and s-wave velocity from MASW/ReMi. In this situation the two techniques may demonstrate a high degree of similarity in the dry situation, but have no apparent correlation if the ground is saturated, particularly if the p-wave velocity of the ground is low.

b) Results from Electrical Resistivity Imaging

The dominant feature in the ERI data is a four layer geometry, with a high-conductivity layer approximately 10m thick at surface. (A thin resistor blanketing the area is not resolved in the sections but it is clearly visible in the data collected for the mat design.) This correlates well with a similar thickness surface layer in the refraction profiles that is defined by a low p-wave velocity, and is mapped as sand in available borehole data. In many areas there is also a good correlation between low velocities in the MASW/ReMi profiles and the low resistivity in the ERI sections.

Beneath the surface layer, there is a layer that is highly variable in thickness and resistivity. On average this more resistive layer often coincides with silty sand and clayey silt. The lateral heterogeneity may reflect changes in porosity linked to variations in lithology, leading to changes in water content.

Beneath this layer, most of the sections exhibit a second increase in resistivity associated with sand, clayey sand and silt, according to the borehole logs. Finally at the base of the ERI sections, a highly resistive interface is reached which correlates very well with intersections of phyllite, quartzite and sandstone in the drill holes.

6.9 Results from the Probabilistic Seismic Hazard Analysis

The results of the seismic hazard analysis are contained within the report tiltled:

"Probabilistic Seismic Hazard Analysis for the Eskom Sere Wind Farm Site, Western Cape. Dated 05 November 2010"

This report is included as Appendix J and the major findings are summarised below.

A site-specific probabilistic seismic hazard assessment has determined site-specific ground-motion parameter values, corresponding to ground motion defined as that motion having a 10% probability of being exceeded over a lifetime of 50 years, (or annual frequency of exceedance (AFE) of 1:475 years). The hazard was determined for rock defined by a shear wave velocity of 750m/s.

The peak ground acceleration (PGA_{475}) value for a return period of 475 years was determined as 0.047g. Spectral acceleration values were also obtained for selected response periods for 1% critical damping. These values were used to prepare mean and median uniform hazard spectra.

Deaggregation showed that the hazard is dominated by nearby sources (13 – 15km) with moderate sized earthquake (5.8 – 6.4). This corresponds to major contribution to the hazard by the Cape Fold Belt West source zone.

These values were calculated by considering a source model that included local and regional seismic sources. The assessment was based on a simplified geological model and existing information only.

It should be noted that only those effects resulting directly from shaking of the ground were considered in this study. No consideration was given to hazard at the site due to surface faulting, and to secondary effects such as tsunamis, landslides or liquefaction.

6.10 Results from the Dynamic Response of the Soil Analysis

The results of the dynamic response of the soil analysis are contained within the report tiltled:

"Dynamic Response of the Soil to Strong Ground Motion, Dated 22 November 2010"

This report is included as Appendix J and the major findings are summarised below.

The report presents the analysis of a dynamic response of the soil to a strong ground motion for the planned Eskom Sere Wind Farm Facility. An assessment of the dynamic response of the soil to strong ground motion was carried out in accordance with the IEC (2005) and GL (2010) standards for the design and safety requirements of wind turbines.

The ground-motion predictions for the site took into consideration the local site conditions in that the following four typical profiles were interpreted from geophysical survey results, percussion drilling results, rotary core drilling results and standard penetration tests and were submitted to the Council for Geoscience as input for seismic hazard analysis:-

- Profile No. 1: Sand to depth
- Profile No. 2: Shallow bedrock
- Profile No. 3: Sand overlying clayey/silty soils, clays and silts
- Profile No. 4: Cemented materials and boulders

The first 50.0m of the shear velocity profile model is based on an average velocity as determined from field measurements. Below 50.0m the velocity model was constructed using material properties obtained from rotary cored boreholes and percussion boreholes as well as some indication from the resistivity investigation. At the Sere Wind Farm site the shear modulus degradation curves and damping ratio curves were selected using generic data suitable for deep soil conditions. The generic curves developed by EPRI (1993) are considered suitable to model pressure-dependent cohesionless soils, soils with gravels, sands, and low PI clays, and were therefore used to model the soil at the Sere Wind Facility.

The seismic hazard analysis described in Section 6.9 of this report, provides uniform hazard spectra (UHS) at bedrock level (Vs=750m/s) and an assessment that most of the hazard comes from a magnitude 6.4 earthquake at a distance of 13 -15 km. The UHS exists for the period range of 0.05 sec to 3.0 sec. Since the natural period of the structure is 3 sec, the UHS was extended to a 4.5 sec period to comply with EC and US standards. As recommended by the GL (2010) guidance, six earthquakes were selected with two independent horizontal components each. The amplitude of the recorded time history was adjusted, so it would match the UHS between 0.05 sec and 4.5 sec period. The modified acceleration records were used as input each of the site types.

In general, it can be said that deeper the base rock level, the larger the value of amplification and higher the value of predominant period. The periods and amplification factors for each site are listed below:

- Profile No. 1 (bedrock depth 150 m) maximal amplification 2.77 at 0.31 sec
- Profile No. 2 (bedrock depth 28 m) maximal amplification 2.51 at 0.25 sec
- Profile No. 3 (bedrock depth 100 m) maximal amplification 2.12 at 0.29 sec
- Profile No. 4 (bedrock depth 100 m) maximal amplification 2.64 at 0.29 sec

The amplification factor caused by the soil column could be quantified by the Ratios of Response Spectra (RRS). The RRS approach forms the basis of the site response coefficients used in many building codes and it is recommended by regulators. Two methods were used to calculate the surface response spectra: one from surface acceleration time history and the second from the average RRS. Similar patterns of response spectra at each of the four typical soil types were observed.

According to the building regulation codes, a band of periods from 0.6 to 6 sec (EC, 2004) or from 0.6 to 4.5 sec (ASCE, 2007) should be analyzed for the structure with a natural period of 3 seconds. Soil columns do not amplify response spectra between

2.0 sec to 4.5 sec, therefore, the fundamental mode of the turbine will not be affected by soil conditions. However, response spectra in the period range 0.6 sec – 2.0 sec are gradually affected by the soil column and at a period of 0.6 sec the amplification factor in comparison to outcrop motion is almost 2. This indicates that the higher mode of the turbine could be affected by soil conditions..

7. GEOTECHNICAL EVALUATION

7.1 Founding Conditions

The following four typical soil profiles were identified at the Sere Wind Facility:

TABLE 7.1: TYPICAL SOIL PROFILES UNDERLYING WIND TURBINES

PROFILE	WIND TURBINE - WTG Number
Sand to depth	1, 2, 4, 14, 18, 21, 33, 35, 48
Shallow Bedrock	19, 26, 28, 29, 30, 31, 32, 36, 38?, 41, 49, 50
Sand overlying clayey/silty soils, clays and silts	6, 10, 12, 16, 20, 22, 23, 24, 25, 27, 34, 37, 39, 40, 43, 44, 46, 47
Cemented Material / Boulders	20

The various typical soil profiles may be generally summarized as follows:

The sand to depth profile is interbedded with clayey sand/sandy clay from 23 – 25m, silty sand from 30 – 45m and clayey silt/silty clay/clay from 45 – 47m.

The shallow bedrock profile is overlain by sand from 0 – 22m, clayey sand/sandy clay from 22 – 24m, clayey silt/silty clay/clay from 24 – 28m intermixed with silty sand.

The sand overlying clayey and silty clays and sands profile comprises sand from 0 – 19m, clayey sand/sandy clay from 19 – 33m, silty sand from 33 – 44m and clayey silt/silty clay/clay from 44 – 48m.

The cemented material/boulders profile consists of sand from 0 - 50m interbedded with sandstone boulders in a matrix of silty sand at 24 – 25m, silty sand from 25 – 31m, cemented materials (calcrete and calcareous silty sand at 31 – 34m, clayey silt/silty clay/clay from 34 – 37m and clayey sand/sandy clay from 37 - 45m.

The laboratory results indicate that the materials on site are not expected to be expansive. However during the site investigation a pin hole voided texture or open texture was noted in some of the sandy material. This is, often, an indication of the presence of a collapsible soil fabric. However, subsequent laboratory testing has confirmed that collapse settlement is negligible on this site. The worst sample tested, WTG16 at 2.4m, had a Collapse Potential of 1.48% which just brings it into the "moderate trouble" category.

It is anticipated that the top loose Aeolian sand will be excavated to spoil. This material is generally not suitable for use in fills as it will be problematic to compact due to its predominantly single grain size.

The wind turbine structures will therefore be founded in the underlying marine deposits.

Foundations should specifically satisfy the following two independent criteria with respect to founding soils:

- The allowable bearing capacity of the founding material.
- Variation in settlement due to consistency/density variations down the profile.

The choice of the most suitable founding option will be dictated by many factors such as economics, nature of the structure in terms of loading, flexibility and tolerance to settlement, variable soil conditions as well as time and space constraints.

7.2 Foundation Types Being Considered

The structures which will house the wind turbines are relatively tall and slender, which by their nature will be sensitive to settlement, especially any differential settlement. Three main types of foundation system are considered appropriate at present:-

a) Caissons

Caissons support the load by the resistance of the soil at their base and by friction between the surface of the caissons and the soil. The lower ends may be enlarged or belled to spread the loads.

b) Piled Foundation

Piles support the load by either the resistance of the soil at their base or by friction between the surface of the piles and the soil or a combination of the two.

The lower ends may also be enlarged or belled to spread compressive loads or resist tension loads.

c) Conventional Pad Footings

Large pad footings support the load by spreading it over a large area thereby decreasing the load per unit area. However, the influence of the raft load will extend to greater depths than the conventional smaller pad footing. This system may include in situ improvement of the in situ materials by dynamic compaction.

The elements within the substation, however, are unlikely to be so sensitive to differential movement and caissons or piles would not normally be considered.

7.3 Bearing Capacity

Utilizing the results from Standard Penetration Tests (SPT) and Dynamic Probe Super Heavy (DPSH) tests, the anticipated allowable bearing capacities at the various wind turbine positions on in-situ soil at a depth of approximately 3.0m have been summarized in Tables 6.3 and 6.4. the values from these two types of test correlate well and indicate that allowable bearing pressures between 200kPa and 500kPa can be expected. The loads from the wind turbine structures are not known at present, but these allowable bearing values are probably more than adequate.

7.4 Assessment of Potential Total and Differential Settlement

The total settlement that occurs under a structure may not be detrimental to the structure if the settlement occurs evenly under the foundation. However, it is known from studies of case records of structures founded on granular soils that the differential settlement can on occasions approach the total settlement. Generally, the differential settlement for granular materials is assumed to be two thirds (i.e. 67%) of the total settlement. This could be detrimental for a tall slender structure like that for a wind turbine.

a) Method of Determining Potential Settlement

In order to determine the potential settlement below the pad footings, the stratigraphy below the footing is needed. This was obtained from the rotary core boreholes, as the information from the percussion boreholes was deemed to be unsuitable for an accurate determination of the different soil layers and their consistencies.

From the core logging, the soil type for each layer has been described and is noted in the rotary core logs e.g. silty sand, clayey sand, silt etc. Due to the disturbance of the soil during the core drilling process, no indication of the in-situ consistency can be adequately determined from the core recovered. Approximate consistency can, however, be determined from the Standard Penetration Tests (SPTs). The greater the SPT value (number of blows/300mm), the more dense or more stiff the material is. Table 7.2 shows the correlation between SPT and consistency of the material, as taken from *'Guidelines for Soil and Rock Logging in South Africa'* and Franki (2008).

TABLE 7.2: CORRELATION BETWEEN SPT "N" VALUE AND CONSISTENCY

Consistency Description	**SPT 'N' (blows per 300mm)**
Sandy materials	
Very loose	<5
Loose	5 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	>50
Clayey Materials	
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30

The SPTs were therefore used to determine the consistency of the corresponding layers in the borehole logs. Where there were no SPTs, consistencies were assumed based on general correlations with other boreholes. In some instances, the horizons or depths at which the consistency changes e.g. from medium dense to dense also had to be assumed. In general, the upper metre is assumed to be loose.

In order to simplify the classification of layers, a number of generalisations have been made:

- There is no distinction between slightly clayey sand and clayey sand, slightly sandy silt and sandy silt etc. The 'slightly' is removed as this is deemed to have no major influence on the E-value.
- Gravel in the layers has been ignored (i.e. scattered, minor and abundant gravel).

- No distinction has been made between loose sand and loose clayey sand, they have both been described as loose sand. As this material is assumed to be removed from below the foundations, this does not affect settlement calculations.
- Gravelly silt has been called sandy silt.
- Weakly cemented silt, silty sand and sandy silt have all been included in weakly cemented sand as it is assumed that they will have similar E-values.

The potential settlement that can occur in each layer is dependent on the stress experienced and the thickness. The actual stress experienced by the ground is dependent on the founding stress and decreases with depth below the design founding level. The stress conditions that are assumed to prevail (from Craig 1983) are shown in Table 7.3, where B is the width of the foundation. It is assumed that the overlying loose material is removed and that the founding stress is applied on the next layer.

TABLE 7.3: DEPTH OF INFLUENCE OF FOUNDING STRESS

Depth Range	Stress (kPa)
Surface to B/2	100% of founding stress
B/2 to B	60% of founding stress
B to 2B	40% of founding stress

As can be seen, only those layers up to a depth of 2B below the founding level are considered as contributing to the potential settlement.

As has been mentioned, Plate Load Testing was carried out at selected positions in order to determine the elastic modulus (otherwise known as E-value or Young's Modulus) of the different soil types; these are considered to be representative of what there is on site. In determining the E-value, the E_{50}-secant on the reload cycle for the vertical tests have been used as this largely eliminates bedding effects. Table 7.4 shows the correlation between the E-value and the material description in the test pit logs.

TABLE 7.4: PLATE LOAD TEST E-VALUES (VERTICAL) AND MATERIAL TYPES

WTG	Depth (m)	E_{50} Secant (MPa)	Log Description
4	2.10	848	Medium dense clayey SAND
16	3.60	316	Medium dense clayey SAND
26	1.00	110	Soft to firm shattered clayey SILT
34	2.80	187	Medium dense to dense with patches of loose clayey SAND
41	1.30	429	Dense weakly cemented clayey silty SAND
46	1.30	285	Dense weakly cemented clayey silty SAND

The value at WTG 4 is seen as an anomaly and will not be considered. In general, the following deductions are made:

- Medium dense sand: 200 – 300 MPa
- Dense sand: 300 – 450 MPa
- Cohesive material: 100 MPa (only one test was done on cohesive material)

Correlations between SPT “N” values and E-values were not deemed suitable for the material on site and have therefore not been used. Due to the slight cementation between particles of the material on site, the final E-values used for the settlement calculations are higher than typical values encountered in literature for clean sands. The E-values are therefore derived directly from the Plate Load Test results and Table 7.5 shows the different material types encountered in the various rotary core boreholes and the corresponding E-value that has been used in assessing potential settlement. It has been assumed that no settlement occurs in rock.

TABLE 7.5: ASSUMED E-VALUES OF MATERIAL ON SITE

E-values	MPa
Loose Sand	100
Medium Dense Sand	250
Dense Sand	350
Very Dense Sand	400
Very weakly cemented sand	350
Weakly cemented sand	375
Cemented Sand	400
Gravel	350
Medium dense clayey sand	250
Dense clayey Sand	350
Very Dense clayey Sand	400
Dense Silty Sand	350
Very dense Silty Sand	400
Medium dense clayey silty sand	250
Dense clayey silty sand	350
Very stiff silt	200
Very stiff clayey silt	200
Very stiff sandy silt	200
Very stiff clayey sandy silt	200
Very stiff silty clay	150

b) Elastic Settlement

As the design and configuration of the wind turbine structure is unknown at present, the base size and founding stress are not known and have been assumed in order to determine the potential settlement. Base sizes of 15m x 15m and 20m x 20m have been assumed with founding stresses of 200kPa, 350kPa and 500kPa.

The elastic settlement of the foundations has been calculated for both base sizes (15mx15m and 20mx20m) and for each different founding stress.

$$\text{Elastic settlement} = \frac{\text{Stress}}{E_{\text{insitu}}} * \text{thickness of layer under consideration}$$

The elastic settlement has been calculated for each layer and then summed at each wind turbine position in order to get the total potential elastic settlement. These values are presented in Table 7.6 below.

TABLE 7.6: ANTICIPATED SETTLEMENTS AT TURBINE BASES

	Elastic Settlement (mm)					
Stress (kPa)	**200**	**350**	**500**	**200**	**350**	**500**
B (m)	**20**	**20**	**20**	**15**	**15**	**15**
WTG 1	15.7	27.5	39.2	12.9	22.6	32.2
WTG 2	12.3	21.6	30.9	9.4	16.4	23.4
WTG 4	11.8	20.7	29.6	8.8	15.5	22.1
WTG 6	12.8	22.4	32.0	8.6	15.1	21.6
WTG 8	17.9	31.4	44.8	11.5	20.2	28.9
WTG 10	21.0	36.7	52.4	15.8	27.6	39.5
WTG 12	14.7	25.7	36.8	10.3	18.0	25.7
WTG 16	16.6	29.1	41.6	11.6	20.3	29.0
WTG 19	12.2	21.3	30.4	9.8	17.2	24.6
WTG 21	13.4	23.4	33.4	10.3	18.0	25.8
WTG 22	13.6	23.8	33.9	10.4	18.2	26.0
WTG 23	16.8	29.5	42.1	11.3	19.7	28.2
WTG 24	13.5	23.6	33.7	10.0	17.5	25.1
WTG 26	22.3	38.9	55.6	16.5	28.8	41.2
WTG 28	11.8	20.6	29.4	10.8	18.8	26.9
WTG 30	12.7	22.3	31.8	10.1	17.8	25.4
WTG 32	12.5	21.8	31.1	9.6	16.8	24.0
WTG 34	12.2	21.4	30.5	9.2	16.1	23.0
WTG 36	17.9	31.3	44.8	11.8	20.6	29.5
WTG 38	8.2	14.4	20.5	4.9	8.6	12.3
WTG 40	16.0	27.9	39.9	11.1	19.4	27.7
WTG 42	12.2	21.4	30.6	8.7	15.2	21.7
WTG 44	11.6	20.2	28.9	8.5	14.9	21.3
WTG 46	18.1	31.7	45.3	12.9	22.7	32.4
WTG 48	12.5	21.9	31.3	9.5	16.6	23.7
WTG 50	11.9	20.8	29.7	8.7	15.3	21.8
WTG 51	12.7	22.2	31.8	9.7	16.9	24.2
WTG 52	17.8	31.1	44.4	12.1	21.1	30.2
WTG 53	13.4	23.4	33.4	9.3	16.2	23.2
WTG 54	17.8	31.2	44.6	13.3	23.3	33.2
ANTICIPATED TOTAL SETTLEMENT:						
Minimum	8.2	14.4	20.5	4.9	8.6	12.3
Average	14.5	25.3	36.2	10.6	18.5	26.5
Maximum	22.3	38.9	55.6	16.5	28.8	41.2
ANTICIPATED DIFFERENTIAL SETTLEMENT (GRANULAR MATERIAL):						
Minimum	5.5	9.6	13.7	3.3	5.8	8.2
Average	9.6	16.9	24.1	7.1	12.3	17.6
Maximum	14.8	26.0	37.1	11.0	19.2	27.5

As can be seen from the above table, the expected differential settlements below the wind turbine bases range from 3.3mm (for a 15m x 15m base at 200kPa) to 37.1mm (for a 20m x 20m base at 500kPa). Although a differential settlement of 3.3mm may be acceptable, it is felt that the magnitude of differential settlement will be unacceptable for the tall slender wind turbine structure. It is therefore recommended that some form of ground improvement is deployed in order to mediate the problem of differential settlement.

c) Consolidation Settlement

In order for consolidation and the resulting settlement to occur, excess pore pressures in the cohesive material (clay and silt) needs to be generated and then dissipated. Given the relatively dry nature of the material on site up to the maximum influence depth of 40m, it is unlikely that the material will ever be saturated enough to allow for the generation and dissipation of excess pore pressures. For this reason, consolidation settlement has not been considered.

7.5 Dynamic Compaction

Dynamic Compaction (DC) is carried out by repeated dropping of a heavy weight (pounder) lifted high above the ground onto footprints set out on a grid pattern. The grid pattern is generally comprised of two or more stages of prints. Primary stage prints are spaced 5 to 10 metres apart with secondary prints evenly spaced between the primary prints. At each print, the pounder is dropped a set number of times from a set height which is referred to as a “pass” before the crater is backfilled with in-situ material bladed from the surafce around the craters or imported material. The depth of improvement is related to the energy per blow (Byrne and Berry, 2008) by:

$$D = k \cdot \sqrt{Wh}$$

Where D = depth of improvement (m)

K = influence factor varying from 0.3 to 1

W = pounder weight (ton)

H = drop height (m)

The final stage of DC comprises ironing with a pounder having a larger flat surface with the prints spaced so as to ensure a minimum overlap of 50%.

The equipment available in South Africa comprises of 60 to 90 tonne crawler cranes with lift range up to 20m and 11 to 14 tonne pounders. It is recommended that in-situ trials are conducted on site in order to assess the effectiveness of the treatment and to optimise the method and DC programme for the site. DC work will then be carried out according to a method specification based on design site trials.

Preliminary calculations have been carried out to assess the dynamic compaction requirements on site. In-situ dry densities were taken from the laboratory tests on the undisturbed samples and maximum dry densities were taken from the laboratory tests for CBRs. This was only possible where both sets of samples had been taken i.e. WTG 16, WTG 34 and WTG 46. The minimum dry density was assumed to be 75% of the maximum, and the density required after DC was assumed to be 1900 kg/m^3.
If the maximum density is taken to be 100% and the minimum density as 0% then relative density (D_R) is determined as follows:

$$D_r = \frac{\gamma_{d\,max}}{\gamma_d} \cdot \frac{\gamma_d - \gamma_{d\,min}}{\gamma_{d\,max} - \gamma_{d\,min}}$$

The D_R for the in-situ density and the required density is determined and then Δ Dr is calculated. These values are shown in Table 7.7.

TABLE 7.7: DYNAMIC COMPACTION INPUT DATA

	WTG16			WTG34	WTG46
Max dry density (kg/m^3)	1920	1920	1920	1915	1900
Min dry density (kg/m^3)	1440	1440	1440	1436	1425
In situ dry density (kg/m^3)	1784	1842	1745	1679	1647
Required density (kg/m^3)	1900	1900	1900	1900	1900
Dr (%) in situ	77	87	70	58	54
Dr (%) required	97	97	97	98	100
Δ Dr (%)	20	10	27	40	46

The depth (Z) and radius (R) of compaction are calculated according to Oshima and Takada (1997):

$$Z = a_z + b_z \log(m \cdot \sqrt{2gH} \cdot N)$$

$$R = a_R + b_R \log(m \cdot \sqrt{2gH} \cdot N)$$

Where a_z b_z a_R b_R are constants

m = mass of pounder in ton

H = drop height (m)

N = number of blows

Preliminary calculations have been done assuming a 14 ton pounder and 18m drop height. Using Byrne and Berry (2008) with an influence factor of 0.5, the depth of improvement is 7.94m. Incorporating the number of blows as per Oshima and Takada, the depth and radius of improvement are shown in Figure 7.1 below.

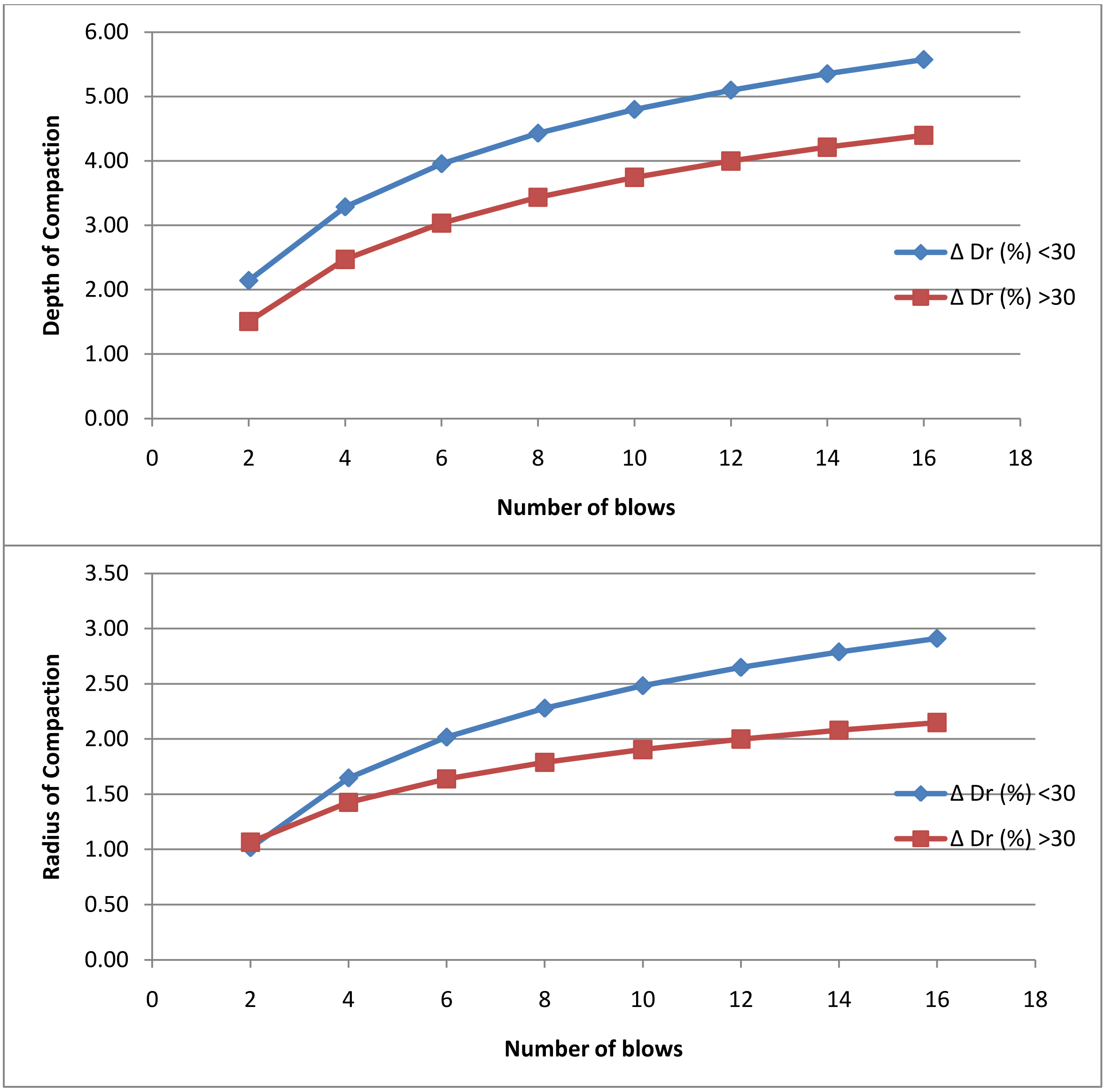

FIGURE 7.1: DEPTH AND RADIUS OF IMPROVEMENT vs BLOW COUNT

Byrne, G., & Berry, A. (2008). *A Guide to Practical Geotechnical Engineering in Southern Africa.* Franki.

Oshima, A., & Takada, N. (1997). Relation between compacted area and ram momentum by heavy tamping. *14th Int Conference SMFE*, (Vol 3, 1641 - 1644). Hamburg.

7.6 Caisson and Piled Foundations

It should be noted that although in the following section the methods outlined for predicting the bearing capacity of piles are based on field and laboratory tests, pile loading tests should be carried out wherever circumstances permit, as a check on the computations.

a) Granular Soils

The load carrying capacity of a caisson or pile installed in granular material can be estimated as follows:

$$P_{ultimate} = A_b * p' * (Nq-1) + A_s * K * p'_{ave} * \tan\phi$$

Where:

$P_{ultimate}$ =	failure load on pile
A_b =	base area of pile
p' =	effective overburden pressure at base of pile
Nq =	bearing capacity factor
A_s =	shaft area of pile
K =	a coefficient of earth pressure
p'_{ave} =	average effective overburden pressure over the length of pile
ϕ =	angle of shear resistance

For concrete elements, Broms (1965) suggests the following values for K in granular soils:

K = 1.0 in loose soils

K = 2.0 in dense soils

The angle of shear resistance may be obtained from Table 6.8 in this report, which summarises the data from shear box tests carried out on samples from the Sere Wind Facility.

When assessing the lateral restraint of the founding structure, the modulus of subgrade reaction may be obtained from Table 6.5 in this report, which summarises the data from plate load tests carried out on samples from the Sere Wind Facility

An overall factor of safety of 2.5 should be utilized, otherwise partial factors of safety of 3 on end bearing and 1.5 on shaft resistance.

b) Cohesive Soils

The load carrying capacity of a caisson or pile installed in cohesive material can be estimated as follows:

$$P_{ultimate} = Nc * A_b * S_u * w + A_s * \alpha * s * S_u'$$

Where:

$P_{ultimate}$ =	failure load on pile
Nc =	bearing capacity factor
A_b =	base area of pile
S_u =	undrained shear strength at base of pile
w =	size factor
A_s =	shaft area of pile
α =	adhesion factor
s =	shape factor
S_u' =	average undrained shear strength over length of pile

The undrained shear strength at the base of the pile may be assumed to be as follows:

S_u = <20kPa for very soft material
20 – 40kPa for soft material
40 – 75kPa for firm material
75 – 150kPa for stiff material
>150kPa for very stiff material
500 – 1000kPa for bedrock

Values for the size factor are as follows:

w = 0.8 for B < 1.0m
0.75 for B > 1.0m

The adhesion factor may be assumed to be as follows:

α = 0.4 for soft material
0.4 for stiff material (for pile length between 8 – 20 diameters)
0.7 for stiff material (for pile length >20 diameters)

The shape factor may be assumed to be as follows:

s = 1.0 for plain shafts
1.2 for tapered shafts

An overall factor of safety of 2.5 should be utilized, otherwise partial factors of safety of 3 on end bearing and 1.5 on shaft resistance.

7.7 Groundwater

No free water was encountered in any of the test pits or rotary core boreholes across the site. Water was however encountered at three windmill turbine positions during percussion drilling at depths ranging from 69m to 79m below ground level. It is unlikely that ground water will be a significant factor on this project

7.8 Liquefaction Potential

Liquefaction is a condition where saturated soils (loose sandy soils and some granular silts) lose shear strength as a result of increased pore pressure and ‘flow’ in a liquid-like behavior during ground shaking (earthquake). The effects of liquefaction on structures are both differential and total settlements as well as loss of foundation support.

The potential for an earthquake is a possibility during the design life of the project, however, given the silty/clayey nature, the density and/or cementation of the soils underlying the site combined with the deep groundwater table, the potential for this phenomenon is considered negligible.

7.9 Earthworks and Stability of Cuts and Fills

To ensure stability, it is recommended that cut slopes have a slope of 1 (vertical) to 1.5 (horizontal) and fill embankments have a slope of 1 (vertical) to 2 (horizontal). This is acceptable for temporary slopes which are dry. Any seepage would require a further inspection, analysis and perhaps flattening.

Prior to placing any fill material, it is recommended that the in-situ material be impact rolled to at least 100% Mod AASHTO density. For fills between 0m to 1.2m in height, the fill material should be :-

- Either placed in layers not exceeding 200mm loose thickness, and compacted by conventional compaction equipment to 100% Modified AASHTO density at

0% to +2% of optimum moisture content. Particles larger than 2/3 of the final layer thickness (after compaction) should not be included in the fill material.

- Or placed in layers not exceeding 500mm loose thickness, and compacted by impact roller to 100% Modified AASHTO density at 0% to +2% of optimum moisture content. Solids larger than 2/3 of the final layer thickness (after compaction) should not be included in the fill material.

For fills greater than 1.2m in height, the fill material should be:-

- Either placed in layers not exceeding 200mm loose thickness, and compacted by conventional compaction equipment to 95% Modified AASHTO density at 0% to +2% of optimum moisture content. Solids larger than 2/3 of the final layer thickness (after compaction) should not be included in the fill material.
- Or placed in layers not exceeding 500mm loose thickness, and compacted by impact roller to 95% Modified AASHTO density at 0% to +2% of optimum moisture content. Solids larger than 2/3 of the final layer thickness (after compaction) should not be included in the fill material.

Both during and after construction, the site should be well graded to permit surface water to drain away readily and to prevent ponding of water anywhere on the ground surface. All terraces and earthworks in general should be sloped to a gradient of not less than 1 (vertical) to 50 (horizontal) to prevent ingress of water into the subsoils since these soils are significantly permeable. Surface drainage should be directed away from the crests of fill embankments to prevent over-topping and erosion of fill slopes.

Erosion protection for both cuts and fills in sands is strongly recommended. Protection procedures may include (but not be restricted to) the following:-

- Rock or gravel protection where the slope surface is covered with a layer of rock or gravel.
- Slope faces can be protected by spreading a layer of topsoil over the slope. The topsoil should contain sufficient grass roots, seed or pioneer plants to establish growth of vegetation on the slope.
- Hydroseeding or planting may be utilised to establish vegetation on embankment slopes.

It is worth noting that the predominantly encountered silts, lean clays and clayey sands may be re-used for engineered fills at site provided that strict moisture control and overall quality control measures are maintained during and following placement and compaction.

7.10 Drainage and Erodability

Foundations and slab performance depends largely on how well runoff waters drain from structures and site in general. It is therefore imperative that the control and removal of both surface and groundwater from the site is closely monitored. Groundwater is not a potential problem on this site, but the natural ingress of stormwater should be managed and controlled to prevent the potential collapse of materials as well as instability of slopes.

It is fundamental that all drainage installations should have adequate capacities to deal with surface runoff and that they should be designed to minimize erosion, ponding and infiltration. The ground surface around structures should be graded so that water flows rapidly away from structures into natural drainage lines without ponding.

7.11 Excavability

The excavability characteristics have been estimated from the performance of the tracked excavator used for the excavation and from the percussion drilled holes. Trenching and excavability may be carried out with earth moving machinery to depth in excess of 5m. However, it is important to note that in the area investigated, unstable trench or test pit side walls were encountered, especially in the upper loose Aeolian deposits. It is thus strongly recommended that the loose Aeolian deposits be removed to spoil prior to excavation and that sidewalls of excavations in the marine deposits be either battered back to 1 (vertical) to 1.5 (horizontal) or shoring be used to ensure stability of the sides of the excavations. Placing of additional loads such as soil heaps and heavy vibrations next to the excavations should be avoided.

It is important to note that large isolated boulders (2.5m to 3m) have been encountered during test pit excavations and isolated rocky outcrops were also observed across the site. These may prove problematic to remove and some boulder splitting (i.e. blasting) may be required.

8. CONCLUSIONS

This report sets out the results of a geotechnical investigation carried out for the Sere Wind Energy Facility. The findings of the field investigations and the available laboratory tests are presented, described and evaluated within this report.

No geotechnical constraints are considered sufficiently significant to prevent development of the site for the use as a Wind Energy Facility.

The following points summarise the findings of this report:

The geotechnical field investigations commenced in July 2010 and were completed in October 2010. The geotechnical field investigations comprised the following:

a) Percussion drilling (at locations alternating with rotary core boreholes),
b) Rotary core drilling (at locations alternating with percussion drilled boreholes),
c) Dynamic Probe Super Heavy (DPSH) testing,
d) Plate load testing,
e) Excavation of test pits
f) Geophysical surveys comprising electrical resistivity survey and seismic refraction surveys

In addition, the following investigations were also carried out:

g) Laboratory testing
h) Seismic hazard assessment
i) Assessment of the dynamic response of the soil

No free water was encountered in any of the test pits or rotary core boreholes across the site. Water was however encountered at three windmill turbine positions during percussion drilling at depths ranging from 69m to 79m below ground level. It is unlikely that ground water will be a significant factor on this project

No grading analyses were carried out on the overlying loose Aeolian sands as these are expected to be excavated to spoil. Based on the grading analyses, the soils in the Sere Wind Facility classify as either SM, SP, SP - SM or SC – SM according to the Unified Soil Classification System. This means that the marine deposits to a depth of approximately 5.0m consist predominantly of poorly graded sand, gravelly sands with little or no fines, or silty sands, poorly graded sand silt mixtures. The results of the laboratory tests confirm that the soils are not plastic indicating that the soil is unlikely to be expansive.

It is anticipated that the top loose Aeolian sand will be excavated to spoil. This material is generally not suitable for use in fills as it will be problematic to compact due to its predominantly single grain size.

Undisturbed block samples of the sand were subjected to Collapse Potential tests The Collapse Potential was generally less than 1% indicating “no trouble” with collapse settlement. Although one sample, WTG16 at 2.4m had a Collapse Potential of 1.48% which just brings it into the “moderate trouble”. Collapse potential is not seen to be problematic in this site.

Shear box testing was undertaken in order to determine the shear strength parameters of the material.

An initial set of tests were carried out on undisturbed dry samples in order to evaluate the shear strength parameters of the in-situ material. These tests produced peak angles of internal friction between 40.5˚ and 46.7˚ with cohesions between 1.1kPa and 157.9kPa. The higher values of cohesion are as a result of the cementing that has taken place in the soil sample.

A second set of tests were carried out on remoulded saturated samples in order to obtain relevant shear strength parameters for material that would be reworked on site. Tests on the remoulded samples produced peak angles of internal friction between 31.1˚ and 35.3˚ with cohesions between 0.5kPa and 2.0kPa.

Selected samples of the near surface samples encountered at site (Borrow Areas A & B) were subjected to chemical analysis to test for pH, resistivity, soluble sulphates and soluble chlorides. assumption has been made that other soils found across the site may be more, less or of a similar corrosive nature.

Selected samples from Borrow Area A and B were subjected to chemical test analysis for the purpose of corrosion assessment. The samples were tested for pH, resistivity, soluble sulphates and soluble chlorides. According to the publication by the Concrete – Durability Bureau of the Portland Cement Institute *(Deterioration of Concrete in Aggressive Waters – Measuring aggressiveness and Taking Countermeasures, Table 3)*, a pH range of 6.67 – 8.87, a water soluble chloride content of 280.20 – 942.80 mg/l and a sulphate concentration of 46.10 – 744.88 mg/l are all considered moderately aggressive.

Resistivity/conductivity tests indicated that the soils range from 0.13 – 0.53 S/m, and this range is considered to be very corrosive to steel.

The seismic refraction data has demonstrated that harder, more competent lithologies such as sandstone and quartzite are likely to be present in the near surface (less than 20m). The existence of such units is, at some sites, confirmed by a sharp increase in shear wave velocity as derived from MASW / ReMi data. However, in some circumstances this correlation does not exist. The lack of correlation between the two techniques is attributed to differences in the way in which the techniques interact with the environment (for example saturated vs unsaturated ground) and its effect on the correlation between p-wave velocity from refraction and s-wave velocity from MASW/ReMi. In this situation the two techniques may demonstrate a high degree of similarity in the dry situation, but have no apparent correlation if the ground is saturated, particularly if the p-wave velocity of the ground is low.

The dominant feature in the ERI data is a four layer geometry, with a high-conductivity layer approximately 10m thick at surface. (A thin resistor blanketing the area is not resolved in the sections but it is clearly visible in the data collected for the mat design.) This correlates well with a similar thickness surface layer in the refraction profiles that is defined by a low p-wave velocity, and is mapped as sand in available borehole data. In many areas there is also a good correlation between low velocities in the MASW/ReMi profiles and the low resistivity in the ERI sections.

Beneath the surface layer, there is a layer that is highly variable in thickness and resistivity. On average this more resistive layer often coincides with silty sand and clayey silt. The lateral heterogeneity may reflect changes in porosity linked to variations in lithology, leading to changes in water content.

Beneath this layer, most of the sections exhibit a second increase in resistivity associated with sand, clayey sand and silt, according to the borehole logs. Finally at the base of the ERI sections, a highly resistive interface is reached which correlates very well with intersections of phyllite, quartzite and sandstone in the drill holes.

A site-specific probabilistic seismic hazard assessment has determined site-specific ground-motion parameter values, corresponding to ground motion defined as that motion having a 10% probability of being exceeded over a lifetime of 50 years, (or annual frequency of exceedance (AFE) of 1:475 years). The hazard was determined for rock defined by a shear wave velocity of 750m/s.

The peak ground acceleration (PGA_{475}) value for a return period of 475 years was determined as 0.047g. Spectral acceleration values were also obtained for selected response periods for 1% critical damping. These values were used to prepare mean and median uniform hazard spectra.

Deaggregation showed that the hazard is dominated by nearby sources (13 – 15km) with moderate sized earthquake (5.8 – 6.4). This corresponds to major contribution to the hazard by the Cape Fold Belt West source zone.

During the assessment of the dynamic response of the soil, the ground-motion predictions for the site took into consideration the local site conditions in that the following four typical profiles were interpreted from geophysical survey results, percussion drilling results, rotary core drilling results and standard penetration tests and were submitted to the Council for Geoscience as input for seismic hazard analysis:-

- Profile No. 1: Sand to depth
- Profile No. 2: Shallow bedrock
- Profile No. 3: Sand overlying clayey/silty soils, clays and silts
- Profile No. 4: Cemented materials and boulders

In general, it can be said that deeper the base rock level, the larger the value of amplification and higher the value of predominant period. The periods and amplification factors for each site are listed below:

- Profile No. 1 (bedrock depth 150 m) maximal amplification 2.77 at 0.31 sec
- Profile No. 2 (bedrock depth 28 m) maximal amplification 2.51 at 0.25 sec
- Profile No. 3 (bedrock depth 100 m) maximal amplification 2.12 at 0.29 sec
- Profile No. 4 (bedrock depth 100 m) maximal amplification 2.64 at 0.29 sec

The structures which will house the wind turbines are relatively tall and slender, which by their nature will be sensitive to settlement, especially any differential settlement. Three main types of foundation system are considered appropriate at present, namely; caissons, piled foundations and conventional pad footings.

Utilizing the results from Standard Penetration Tests (SPT) and Dynamic Probe Super Heavy (DPSH) tests, the anticipated allowable bearing capacities at the various wind turbine positions range between 200kPa and 500kPa. The loads from the wind turbine structures are not known at present, but these allowable bearing values are probably more than adequate.

The total settlement that occurs under a structure may not be detrimental to the structure if the settlement occurs evenly under the foundation. However, it is known from studies of case records of structures founded on granular soils that the differential settlement can on occasions approach the total settlement. Generally, the differential settlement for granular materials is assumed to be two thirds (i.e. 67%) of the total settlement. This could be detrimental for a tall slender structure like that for a wind turbine.

The expected differential settlements below the wind turbine bases range from 3.3mm (for a 15m x 15m base at 200kPa) to 37.1mm (for a 20m x 20m base at 500kPa). Although a differential settlement of 3.3mm may be acceptable, it is felt that in general the magnitude of differential settlement will be unacceptable for the tall slender wind turbine structure. It is therefore recommended that some form of ground improvement is deployed in order to mediate the problem of differential settlement.

In order for consolidation and the resulting settlement to occur, excess pore pressures in the cohesive material (clay and silt) needs to be generated and then dissipated. Given the relatively dry nature of the material on site up to the maximum influence depth of 40m, it is unlikely that the material will ever be saturated enough to allow for the generation and dissipation of excess pore pressures. For this reason, consolidation settlement has not been considered.

Dynamic compaction has been considered as a ground improvement technique below conventional pad footings for the wind turbine structures. Preliminary calculations have been done assuming a 14 ton pounder and 18m drop height. Using Byrne and Berry (2008) with an influence factor of 0.5, the depth of improvement is 7.94m.

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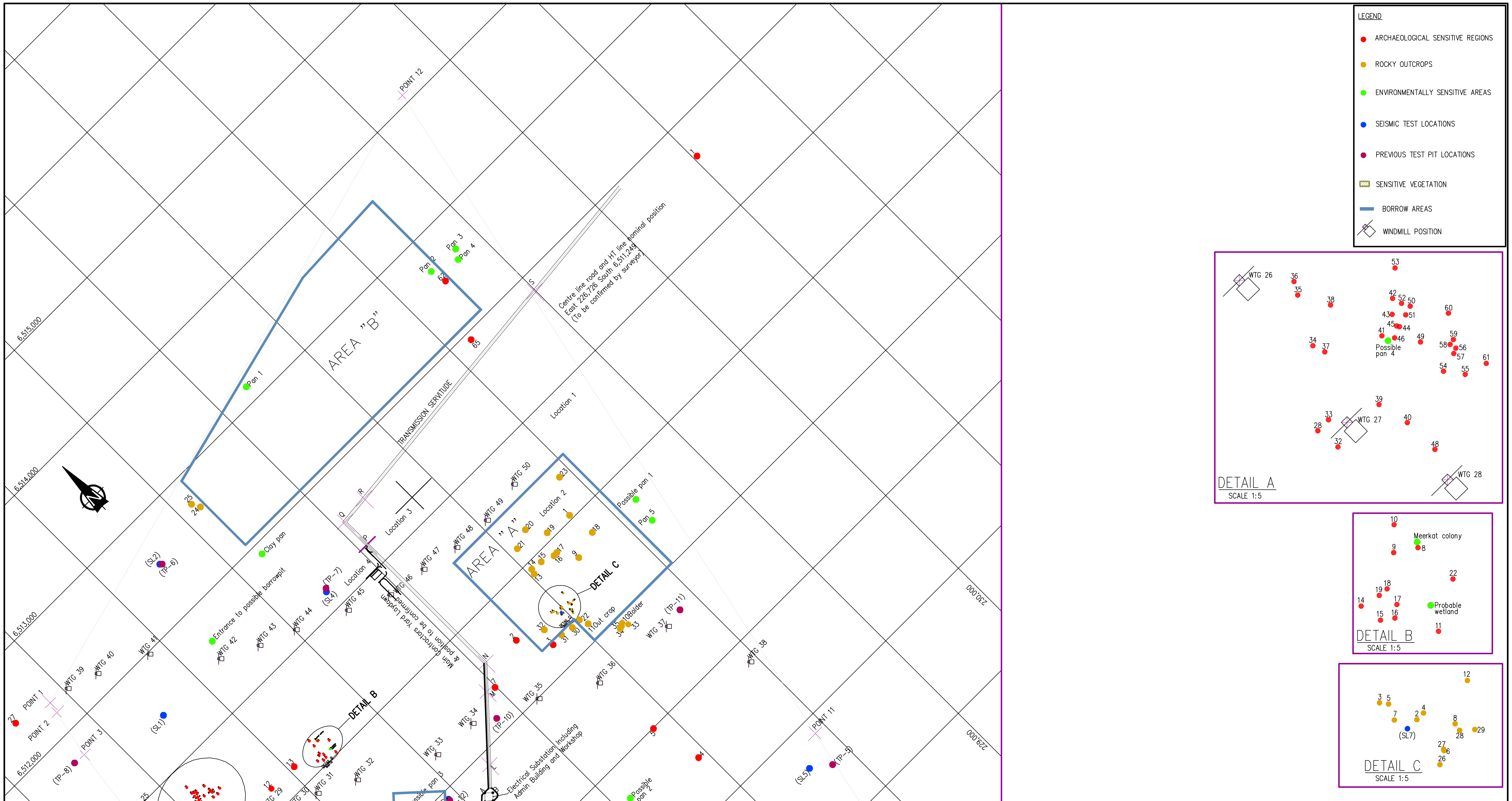


REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

Client:

Eskom

Consultant:

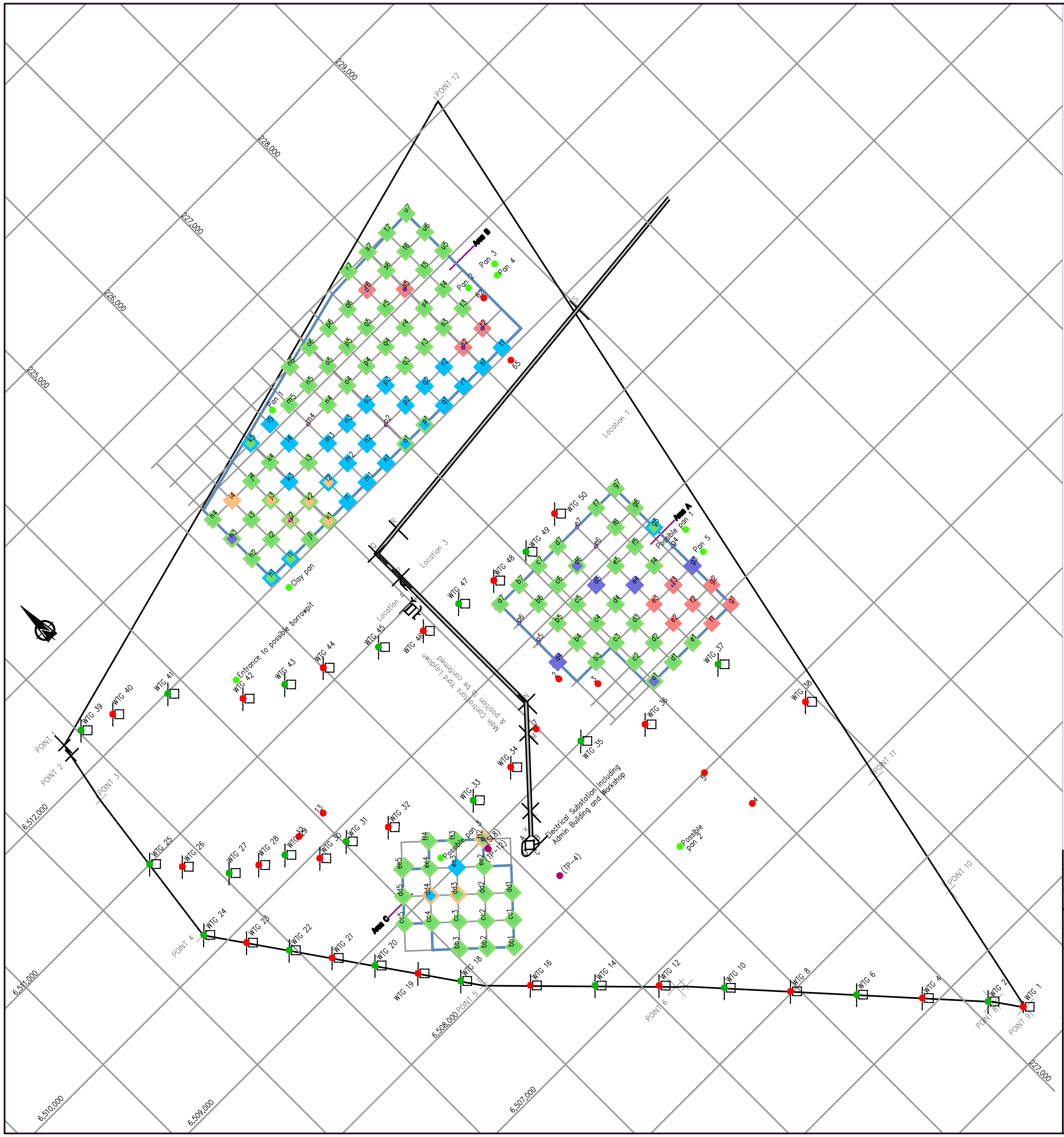
BKS Palace Consortium

In association with MWH

SERE WIND FARM

ENVIRONMENTALLY SENSITIVE AREAS

Drawing Number: J01386-004-117-01-R-00



<u>WINDMILL POSITIONS LEGEND</u>

- WINDMILL POSITION
- PERCURSION
- PRIMARY ROTARY CORE

<u>NOTES</u>

1. DRILLING POSITIONS WTG 3, 5, 7, 9, 11, 13, 15 AND 17 NO LONGER TO BE INVESTIGATED/DRILLED AT ESKOM REQUEST.
2. CO-ORDINATES FOR 4 CORNERS OF THE SUBSTATION NOW INCLUDED.

<u>LEGEND</u>

- ARCHAEOLOGICAL SENSITIVE REGIONS
- ENVIRONMENTALLY SENSITIVE AREAS
- BORROW AREAS
- WINDMILL POSITION

<u>SUBSOIL LEGEND</u>

- SANDSTONE BEDROCK
- STRONGLY CEMENTED "PEDOGENIC"
- SLIGHTLY SILTY SAND
- SANDY CLAY / CLAYEY SAND
- AEOLIAN SAND

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

Client: Eskom

Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

WINDMILL AND BORROW PIT TEST PIT POSITIONS

Drawing Number: J01386-004-117-02-R-00

SITE BOUNDARY COORDINATES
UTM SYSTEM (meters, Kilometers)

NAME	EAST	SOUTH
POINT 1	222 821.18	6 512 324.92
POINT 2	222 798.37	6 512 213.80
POINT 3	222 697.14	6 511 734.67
POINT 4	222 490.99	6 510 189.89
POINT 5	223 981.87	6 508 045.20
POINT 6	225 221.56	6 506 788.20
POINT 7	225 287.48	6 506 728.67
POINT 8	227 186.85	6 504 626.76
POINT 9	227 351.69	6 504 390.77
POINT 10	227 619.44	6 505 639.16
POINT 11	227 877.52	6 506 845.97
POINT 12	229 427.22	6 514 081.58

CO-ORDINATE LIST OF TEST PIT POSITIONS BORROW AREA A

NAME	EAST	SOUTH
A4	226562.2649	6509664.5615
A5	226562.2649	6509914.5615
A6	226562.2649	6510164.5615
A7	226562.2649	6510414.5615
B3	226812.2649	6509414.5615
B4	226812.2649	6509664.5615
B5	226812.2649	6509914.5615
B6	226812.2649	6510164.5615
B7	226812.2649	6510414.5615
C1	227062.2649	6508914.5615
C2	227062.2649	6509164.5615
C3	227062.2649	6509414.5615
C4	227062.2649	6509664.5615
C5	227062.2649	6509914.561
C6	227062.2649	6510164.5615
C7	227062.2649	6510414.5615
D1	227312.2649	6508914.5615
D2	227312.2649	6509164.5615
D3	227312.2649	6509414.5615
D4	227312.2649	6509664.5615
D5	227312.2649	6509914.5615
D6	227312.2649	6510164.5615
D7	227312.2649	6510414.5615
E1	227562.2649	6508914.5615
E2	227562.2649	6509164.5615
E3	227562.2649	6509414.5615
E4	227562.2649	6509664.5615
E5	227562.2649	6509914.5615
E6	227562.2649	6510164.5615
E7	227562.2649	6510414.5615
F1	227812.2649	6508914.5615
F2	227812.2649	6509164.5615
F3	227812.2649	6509414.5615
F4	227812.2649	6509664.5615
F5	227812.2649	6509914.5615
F6	227812.2649	6510164.5615
F7	227812.2649	6510414.5615
G1	228062.2649	6508914.5615
G2	228062.2649	6509164.5615
G3	228062.2649	6509414.5615
G4	228062.2649	6509664.5615
G5	228062.2649	6509914.5615
G6	228062.2649	6510164.5615
G7	228062.2649	6510414.5615

CO-ORDINATE LIST OF TEST PIT POSITIONS BORROW AREA B

NAME	EAST	SOUTH
H1	225250.0000	6512068.4822
H2	225250.0000	6512318.4822
H3	225250.0000	6512576.3035
H4	225250.0000	6512826.3035
I1	225500.0000	6512068.4822
I2	225500.0000	6512318.4822
I3	225500.0000	6512576.3035
I4	225500.0000	6512826.3035
J1	225750.0000	6512068.482
J2	225750.0000	6512318.4822
J3	225750.0000	6512576.3035
J4	225750.0000	6512826.3035
K1	225990.6507	6512068.4822
K2	225990.6507	6512318.4822
K3	225990.6507	6512576.3035
K4	225990.6507	6512826.3035
K5	225990.6507	6513076.3035
L1	226240.6507	6512068.4822
L2	226240.6507	6512318.4822
L3	226240.6507	6512576.3035
L4	226240.6507	6512826.3035
L5	226240.6507	6513076.3035
M1	226490.6507	6512068.4822
M2	226490.6507	6512318.4797
M3	226490.6507	6512576.3035
M4	226490.6507	6512826.3035
M5	226490.6507	6513076.3035
N1	226740.6507	6512068.4822
N2	226740.6507	6512318.4822
N3	226740.6507	6512576.3035
N4	226740.6507	6512826.3035
N5	226740.6507	6513076.3035
N6	226740.6507	6513317.0184
O1	226990.6507	6512068.4822
O2	226990.6507	6512318.4822
O3	226990.6507	6512576.3035
O4	226990.6507	6512826.3035
O5	226990.6507	6513076.3035
O6	226990.6507	6513317.0184
P1	227240.6507	6512068.4822
P2	227240.6507	6512318.4822
P3	227240.6507	6512576.3035
P4	227240.6507	6512826.3035
P5	227240.6507	6513076.3035
P6	227240.6507	6513317.0184
Q1	227490.6507	6512068.4822
Q2	227490.6507	6512318.482
Q3	227490.6507	6512576.3035
Q4	227490.6507	6512826.3035
Q5	227490.6507	6513076.3035
Q6	227490.6507	6513317.0184
R1	227740.6507	6512068.4822
R2	227740.6507	6512318.4822
R3	227740.6507	6512576.3035
R4	227740.6507	6512826.3035
R5	227740.6507	6513076.3035
R6	227740.6507	6513317.0184
R7	227740.6507	6513557.7333
S1	227990.6507	6512068.4822
S2	227990.6507	6512318.4822
S3	227990.6507	6512576.3035
S4	227990.6507	6512826.3035
S5	227990.6507	6513076.3035
S6	227990.6507	6513317.0184
S7	227990.6507	6513557.7333
T1	228240.6507	6512068.4822
T2	228240.6507	6512318.4822
T3	228240.6507	6512576.3035
T4	228240.6507	6512826.3035
T5	228240.6507	6513076.3035
T6	228240.6507	6513317.0184
T7	228240.6507	6513557.7333
U5	228490.6507	6513076.3035
U6	228490.6507	6513317.0184
U7	228490.6507	6513557.7333

CO-ORDINATE LIST OF TEST PIT POSITIONS BORROW AREA C

NAME	No	EAST	SOUTH
BB1	1	224430.8859	6508096.464
BB2	2	224247.673	6508266.561
BB3	3	224064.4602	6508436.658
BB4	4	223881.2473	6508606.755
CC1	6	224600.9831	6508279.677
CC2	7	224417.7702	6508449.774
CC3	8	224234.5574	6508649.871
CC4	9	224051.3445	6508789.968
CC5	10	223868.1316	6508960.065
DD1	11	224771.0802	6508462.889
DD2	12	224587.8674	6508632.987
DD3	13	224404.6545	6508803.084
DD4	14	224221.4417	6508973.181
DD5	15	224038.2288	6509143.278
EE2	17	224757.9646	6508816.199
EE3	18	224574.7517	6508986.297
EE4	19	224391.5389	6509156.394
EE5	20	224208.326	6509326.491
FF2	22	224928.0617	6508999.412
FF3	23	224744.8489	6509169.51
FF4	24	224561.636	6509339.607

CO-ORDINATE LIST OF WINDMILL POSITIONS

NAME	No	EAST	SOUTH
WTG	1	227344.2702	6504407.091
WTG	2	227151.2749	6504670.130
WTG	4	226746.3644	6505118.767
WTG	6	226341.5456	6505567.222
WTG	8	225934.8934	6506017.968
WTG	10	225528.6078	6506469.722
WTG	12	225119.3888	6506907.542
WTG	14	224705.0362	6507322.995
WTG	16	224286.6501	6507743.214
WTG	18	223863.1304	6508223.937
WTG	19	223635.4199	6508550.652
WTG	20	223408.076	6508880.667
WTG	21	223178.532	6509207.749
WTG	22	222950.4547	6509535.564
WTG	23	222722.7441	6509862.646
WTG	24	222495.0335	6510189.728
WTG	25	222603.9386	6511000.466
WTG	26	222798.9608	6510771.637
WTG	27	223061.2858	6510426.513
WTG	28	223305.813	6510287.225
WTG	29	223541.0543	6510181.986
WTG	30	223745.3428	6509934.363
WTG	31	224027.0133	6509872.458
WTG	32	224392.2563	6509692.931
WTG	33	225117.3257	6509315.307
WTG	34	225575.4272	6509287.450
WTG	35	226200.5557	6509003.506
WTG	36	226724.9369	6508694.123
WTG	37	227588.5201	6508610.551
WTG	38	227911.9769	6507799.587
WTG	39	223028.0116	6512314.634
WTG	40	223337.5396	6512212.490
WTG	41	223828.1415	6511988.082
WTG	42	224283.9215	6511469.622
WTG	43	224646.0693	6511290.096
WTG	44	225004.348	6511149.261
WTG	45	225497.2714	6510924.853
WTG	46	225893.4673	6510739.136
WTG	47	226298.949	6510686.516
WTG	48	226676.5732	6510609.134
WTG	49	227072.769	6510587.467
WTG	50	227506.1083	6510649.373

CO-ORDINATE LIST ARCHAEOLOGICAL SENSITIVE REGIONS

NAME	No	EAST	SOUTH
Defalation hollow site with ephemeral scatter of LSA.	1	231038	6511637
Ferricrete outcrop.	2	226460	6509547
Ferricrete outcrop with MSA scatter.	3	226683	6509263
Deflated msa scatter	4	226907	6507485
Ferricrete with msa scatter.	5	226796	6507995
Ephemeral LSA midden.	7	225989	6509369
Large LSA midden with stone artefacts,ceramic.	8	224400	6510222
LSA midden with stone artefacts.	9	224341	6410210
LSA midden with stone artefacts.	10	224342	6510278
Ephemeral LSA midden.	11	224450	6510019
Ephemeral LSA midden.	12	223752	6510211
Ephemeral LSA midden.	13	224060	6510206
Ephemeral LSA midden.	14	224262	6510080
Dense LSA midden with stone artefacts.	15	224309	6510046
Ephemeral LSA midden.	16	224344	6510051
LSA midden.	17	224349	6510084
LSA midden.	18	224325	6510122
Ephemeral LSA midden.	19	224306	6510106
Ephemeral LSA midden.	22	224485	6510146
LSA midden.	27	222443	6512423
Ephemeral LSA midden.	28	222990	6510406
LSA midden.	29	222223	6511311
Dense LSA midden with stone artefacts.	30	222268	6511283
Dense LSA midden with stone artefacts.	31	222259	6511289
Ephemeral LSA midden.	32	223039	6510367
Ephemeral LSA midden.	33	223016	6510433
LSA midden.	34	222978	6510613
LSA midden.	35	222941	6510736
LSA midden.	36	222932	6510769
Dense LSA midden with stone artefacts.	37	223007	6510598
LSA midden.	38	223021	6510712
Dense LSA midden with stone artefacts.	39	223139	6510470
LSA midden.	40	223208	6510426
LSA midden.	41	223146	6510637
LSA midden.	42	223172	6510728
LSA midden.	43	223171	6510689
LSA midden.	44	223189	6510659
LSA midden.	45	223182	6510661
LSA midden.	46	223177	6510632
LSA midden with ceramics.	48	223275	6510361
Ephemeral LSA midden.	49	223240	6510622
Ephemeral LSA midden.	50	223215	6510709
Ephemeral LSA midden.	51	223204	6510688
Ephemeral LSA midden.	52	223194	6510716
LSA midden.	53	223178	6510802
LSA midden with ceramics.	54	223296	6510551
Ephemeral LSA midden.	55	223349	6510543
Ephemeral LSA midden.	56	223326	6510607
Ephemeral LSA midden.	57	223321	6510594
Ephemeral LSA midden.	58	223312	6510616
Ephemeral LSA midden.	59	223320	6510628
Ephemeral LSA midden.	60	223308	6510692
Ephemeral LSA midden.	61	223400	6510570
Ephemeral LSA scatter in deflation hollow midden.	62	228446	6512508
Ephemeral LSA scatter in deflation hollow midden.	65	228219	6511928

CO-ORDINATE LIST OF ENVIROMENTALLY SENSITIVE AREAS

NAME	EAST	SOUTH
Clay Pan	225305	6511892
Entrance to possible borrowpit	224361	6511634
Meerkat Colony	224398	6510236
Pan 1	226347	6513151
Pan 2	228413	6512672
Pan 3	228737	6512659
Pan 4	228682	6512569
Pan 5	228222	6509438
Possible Pan 1	228253	6509694
Possible Pan 2	226158	6507675
Possible Pan 3	224532	6509152
Possible Pan 4	223161	6510625
Probable Wetland	224431	6510082
Sealed Surface (roof-structure)	227255	6504641

CO-ORDINATE LIST OF ROCKY OUTCROPS

NAME	No	EAST	SOUTH
Large area, near windmil	1	227687	6510041
a)Large, part of the outcrop.	2	226984	6509452
a)Small, part of the outcrop trend.	3	226893	6509493
b)Large, part of the outcrop trend	4	227000	6509468
b)Small, part of the outcrop trend.	5	226915	6509490
c)Large, part of the outcrp trend.	6	227050	6509377
c)Small, part of the outcrop trend.	7	226929	6509451
d)Small, part of the outcrop trend.	8	227077	6509442
Medium size boulders.	9	227459	6509686
Boulders.	10	227310	6508939
Outcrop	11	227068	6509166
Outcrop	12	227107	6509547
Outcrop	13	227039	6509880
Outcrop	14	227055	6509930
Outcrop	15	227172	6509916
Outcrop	16	227302	6509870
Outcrop	17	227343	6509872
Outcrop	18	227726	6509767
Outcrop	19	227413	6510075
Outcrop	20	227284	6510246
Outcrop	21	227098	6510171
Outcrop	22	227035	6509253
Outcrop	23	227881	6510373
Outcrop	24	225203	6512640
Outcrop	25	225161	6512720
Outcrop	26	227040	6509343
Outcrop	27	227049	6509380
Outcrop	28	227088	6509426
Outcrop	29	227125	6509428
Outcrop	30	226933	6509249
Outcrop	31	226808	6509274
Outcrop	32	226725	6509426
Outcrop	33	227340	6508886
Outcrop	34	227256	6508913
Outcrop	35	227282	6508922
Outcrop	36	224312	6508257
Outcrop	37	224414	6508458

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

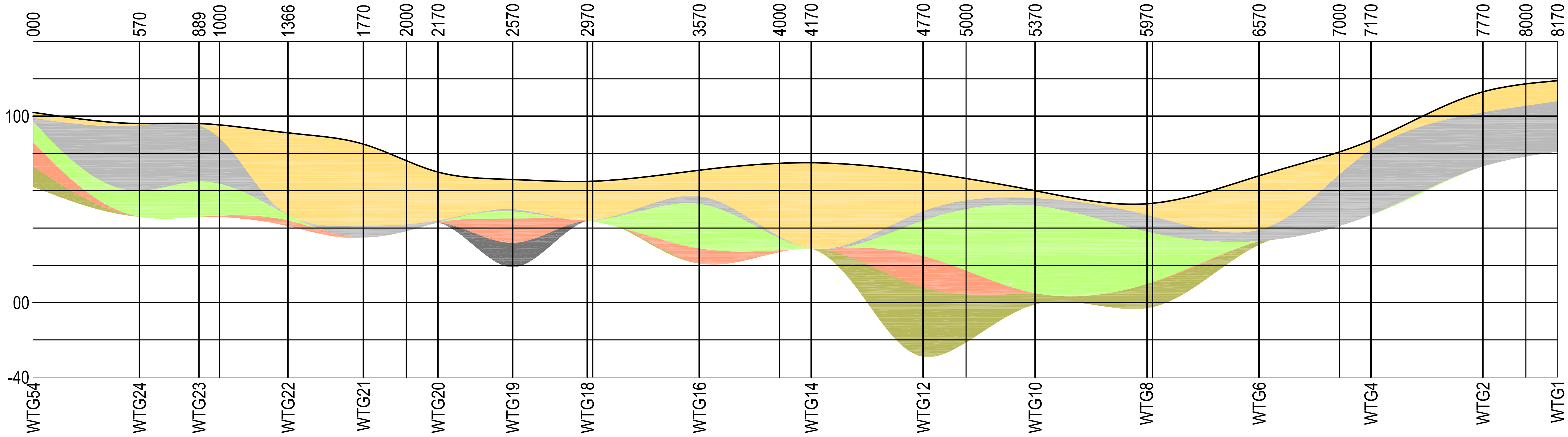
Client:
Eskom

Consultant:
BKS Palace Consortium
BKS
In association with
MWH

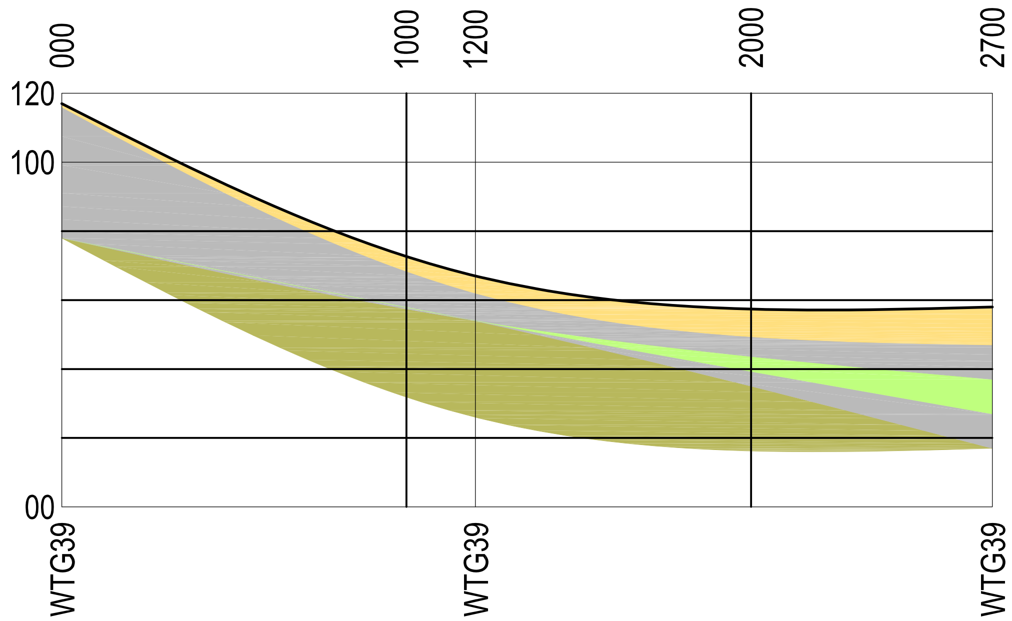
SERE WIND FARM

WINDMILL POSITIONS COORDINATES

Drawing Number: J01386-004-117-03-R-00



LINE 1



LINE 1 ADDITIONAL HOLES

LEGEND

- SAND Aeolian
- Sand Marine
- SILT Marine
- Residual Quartzite
- Residual Phylite
- Rock SANDSTONE

NOTE: ORIGINAL SCALE (A1)
H 1:1000
V 1:100

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

Client: Eskom

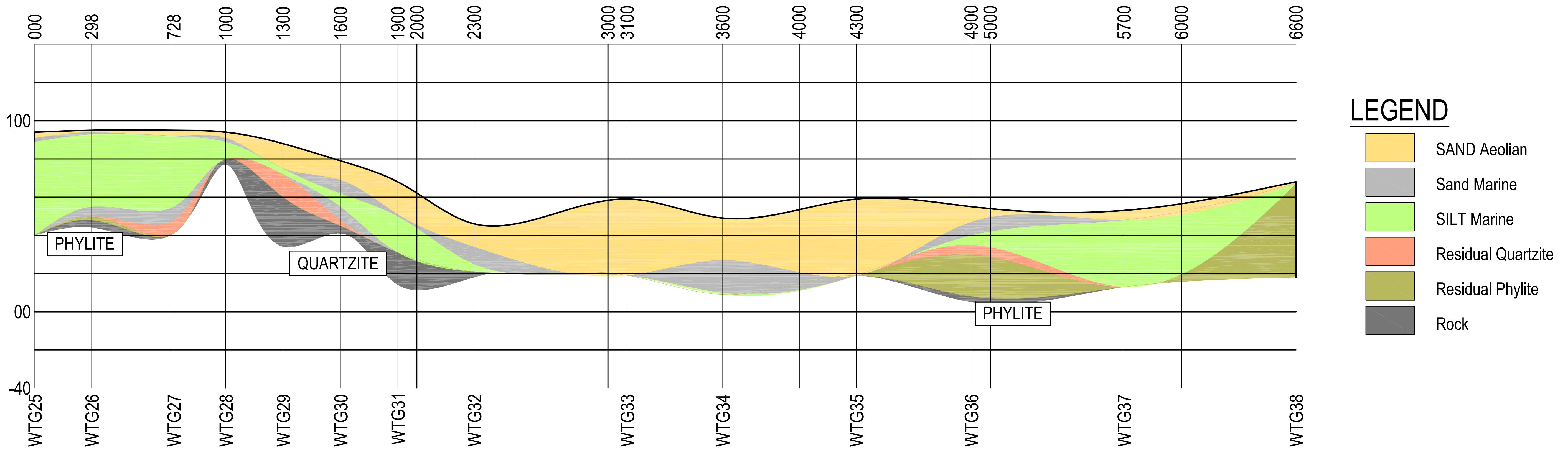
Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

GEOLOGICAL LONGSECTION ALONG LINE 1

Drawing Number: J01386-004-117-04-R-00



LINE 2

NOTE: ORIGINAL SCALE (A1)
H 1:1000
V 1:100

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

Client: Eskom

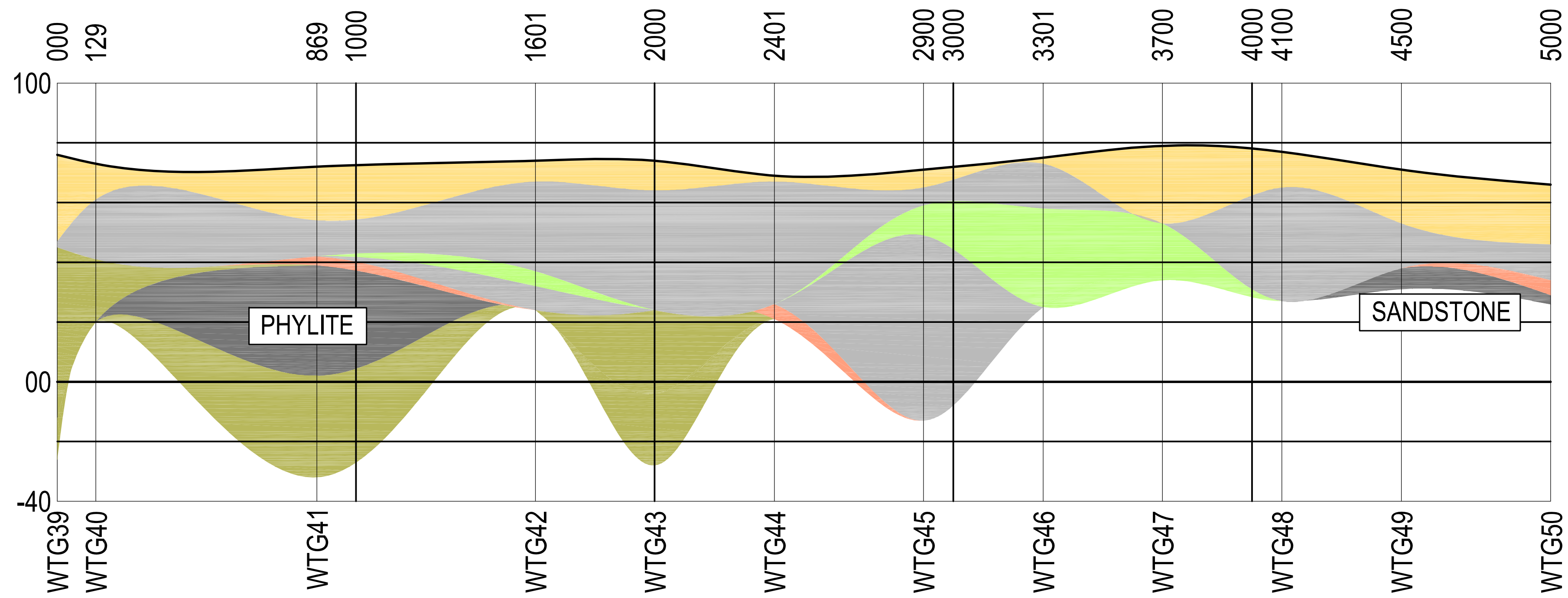
Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

GEOLOGICAL LONGSECTION ALONG LINE 2

Drawing Number: J01386-004-117-05-R-00



LINE 3

LEGEND

- SAND Aeolian
- Sand Marine
- SILT Marine
- Residual Quartzite
- Residual Phylite
- Rock

NOTE: ORIGINAL SCALE (A1)
H 1:1000
V 1:100

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale:
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	AS SHOWN

Client: Eskom

Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

GEOLOGICAL LONGSECTION ALONG LINE 3

Drawing Number: J01386-004-117-06-R-00

REV NO:	DESCRIPTION					DATE
AUTH:	T DA SILVA	CHKD:	H J TLUCZEK	DRAWN:	M SCOTT	Scale: N. T. S.
DATE:	11/2010	DATE:	11/2010	DATE:	11/2010	

Client: Eskom

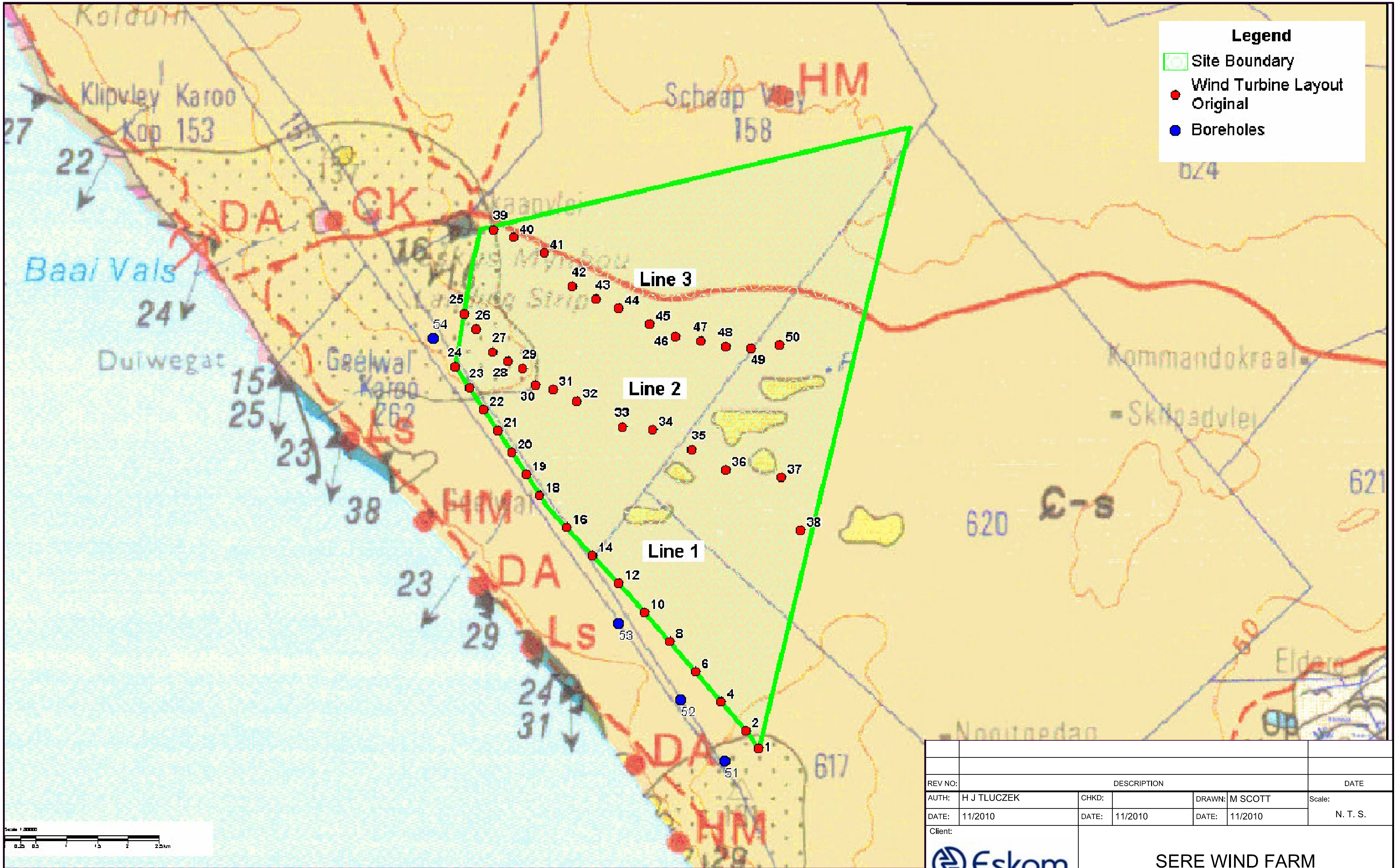
Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

FIGURE 1
LOCALITY PLAN

Drawing Number:



REV NO:	DESCRIPTION				DATE
AUTH: H J TLUCZEK	CHKD:		DRAWN: M SCOTT		Scale: N. T. S.
DATE: 11/2010	DATE: 11/2010		DATE: 11/2010		

Client: Eskom

Consultant: BKS Palace Consortium

In association with MWH

SERE WIND FARM

GEOLOGY AND
PROPOSED WIND TURBINE POSITIONS

Drawing Number: FIGURE 2

APPENDIX C:

SOIL AND ROCK DESCRIPTIVE TERMS

BKS Palace Consortium

ESKOM
SERE WIND ENERGY FACILITY
GEOTECHNICAL INVESTIGATION

LEGEND
Sheet 1 of 1

JOB NUMBER: J01386

	BOULDERS	{SA01}
	GRAVEL	{SA02}
	GRAVELLY	{SA03}
	SAND	{SA04}
	SANDY	{SA05}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SANDSTONE	{SA11}
	QUARTZITE	{SA15}
	PHYLLITE	{SA47}
	FERRICRETE	{SA24}
	CALCRETE	{SA26}
13.5	PERMANENT WATER TABLE	{SA35}
Name	UNDISTURBED SAMPLE	{SA37}
Name	DISTURBED SAMPLE	{SA38}
Name	CHEMICAL SAMPLE	{SA39}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

TYPE SET BY :
SETUP FILE : V.SET

INCLINATION :
DIAM :
DATE :
DATE :

DATE : 04/11/10 08:51
TEXT : ..\TEXT\SEREWI~1.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

SOIL DESCRIPTIVE TERMS (**Guide to Core logging for Civil Engineering Purposes,(1993)**

DESCRIPTIVE ORDER: 1. CONSISTENCY 2. SOIL TYPE 3. MOISTURE CONDITION 4. COLOUR 5. SOIL STRUCTURE 6. ORIGIN

1.(a) CONSISTENCY : GRANULAR SOILS.

S P T "N"	GRAVELS & SANDS Generally free draining soils		TYPICAL DRY DENSITY (kg/m^2)
<4	VERY LOOSE	Crumbles very easily when scraped with geological pick	<1450
4–10	LOOSE	Small resistance to penetration by sharp pick point	1450-1600
10–30	MEDIUM DENSE	Considerable resistance to penetration by sharp pick point	1600-1725
30-50	DENSE	Very high resistance to penetration by sharp pick point. Requires many blows of pick for excavation	1750-1925
>50	VERY DENSE	High resistance to repeated blows of geological pick. Requires power tools for excavation	>1925

S P T "N"	SILTS & CLAYS and combinations with SANDS Generally slow draining soils		U.C.S. (kPa)
<2	VERY SOFT	Pick point easily pushed in 100mm Easily moulded by fingers	<50
2–4	SOFT	Pick point easily pushed in 30-40mm. Moulded by fingers with some pressure. Easily penetrated by thumb.	50-12500
4-8	FIRM	Pick point penetrates up to 10mm. Very difficult to mould with fingers. Indented by thumb with effort. Spade just penetrates.	125-250
8-15	STIFF	Slight indentation by pushing in pick point. Cannot be moulded by fingers. Penetrated by thumb nail. Pick necessary to excavate	250-500
15-30	VERY STIFF	Slight indentation by blow of pick point. Requires power tools for excavation.	500-1000

2 SOIL TYPE

SOIL TYPE.	PARTICLE SIZE (mm)
CLAY	<0,002
SILT	0,002 – 0,06
SAND	0,06 – 2
GRAVEL	2 – 60
COBBLES	60 – 200
BOULDERS	>200

* Specify ave/max sizes, hardness, shape and proportion

3. MOISTURE CONDITION

DRY	No water detectable
SLIGHTLY MOIST	Water just discernable
MOIST	Water easily discernable
VERY MOIST	Water can be squeezed out
WET	Generally below the water table

4. COLOUR

Described at natural moisture content, as seen in profile (unless otherwise specified)

SPECKLED	Very small patches of colour <2 mm
MOTTLED	Irregular patches of colour 2 – 6mm
BLOTCHED	Large irregular patches 6 – 20 mm
BANDED	Approximately parallel bands of varying colour
STREAKED	Randomly orientated streaks of colour
STAINED	Local colour variations : associated with discontinuity surfaces
Described using bedding thickness criteria, (e.g. thickly banded, thinly streaked etc.)	

5 SOIL STRUCTURE

INTACT	No structure present
FISSURED	Presence of discontinuities, possibly cemented.
SLICKENSIDED	Very smooth, glossy, often striated discontinuity planes
SHATTERED	Presence of open fissures. Soil breaks into gravel size
MICRO-SHATTERED	Small scale shattering, very closely spaced open fissures. Soil breaks into sands size crumbs
RESIDUAL STRUCTURES	Relict bedding, lamination, foliation, etc.

6. ORIGIN

TRANSPORTED	Alluvium, hillwash, talus, etc.
RESIDUAL	Weathered from parent rock e.g. residual granite
PEDOCRETES	Ferricrete, laterite, silcrete, clacrete, etc.

DEGREE OF CEMENTATION OF PEDOCRETES	
VERY WEAKLY CEMENTED	Some material can be crumbled between finger and thumb. Disintegrates under knife blade to a friable state
WEAKLY CEMENTED	Cannot be crumbled between strong fingers. Some material can be crumbled by strong pressure between thumb and hard surface. Under light hammer blows disintegrates to friable.
CEMENTED	Material crumbles under firm blows of sharp pick point. Grains can be dislodged with some difficulty by a knife blade.
STRONGLY CEMENTED	Firm blows of sharp pick point on hand-held specimen show 1-3mm indentations. Grains cannot be dislodged by knife blade
V. STRONGLY CEMENTED	Hand-held specimen can be broken by single firm blow of hammer head. Similar appearance to concrete.

ROCK DESCRIPTIVE TERMS (from Guide to Core logging for Civil Engineering Purposes,1993)

DESCRIPTIVE ORDER: 1. HARDNESS 2. ROCK TYPE 3. WEATHERING 4. COLOUR 5. FRACTURE SPACING 6. DISCONTNUITY SURFACE DESCRIPTION 7. GRAIN SIZE 8. ROCK FORMATION NAME

1. ROCK HARDNESS

HARDNESS	DESCRTIPTION	U.C.S. MPa
VERY SOFT ROCK	Material crumbles under firm blows of pick point. Can be peeled with a knife. SPT refusal. Too hard to cut triaxial sample by hand.	1-3
SOFT ROCK	Firm blows with pick point : 2-4mm indents. Can just be scraped with a knife.	3-10
MEDIUM HARD ROCK	Firm blows of pick head will break hand-held specimen. Cannot be scraped or peeled with a knife.	10.25

HARDNESS	DESCRIPTION	U.C.S. MPa
HARD ROCK	Breaks with difficulty, rings when struck Point load or laboratory test results necessary to distinguish between categories	25-70
VERY HARD ROCK		70-200
VERY VERY HARD ROCK		>200

2 ROCK TYPE

Quartzite, sandstone, granite, limestone, etc.

4. COLOUR

Described in the dry state unless otherwise indicated

3. WEATHERING

DEGREE OF WEATHERING	EXTENT OF DISCOLOURATION	FRACTURE CONDITION	SURFACE3 CHARACTERISTICS	ORIGINAL FABRIC	GRAIN BOUNDARY CONDITION
UNWEATHERED	None	Closed or stained	Unchanged	Preserved	Tight
SLIGHTLY WEATHERED	<20 % of fracture spacing on both sides of fracture.	Discoloured, may contain thick filling	Partial discolouration. Often unweathered rock colour	Preserved	Tight
MODERATELY WEATHERED	<20 % of fracture spacing on both sides of fracture.	Discoloured, may contain thick filling	Partial to complete discolouration. Not friable except poorly cemented rocks	Preserved	Partial opening
HIGHLY WEATEHRED	Throughout	-	Friable, possibly pitted	Mainly preserved	Partial separation. Not easily indented with knife. Does not slake
COMPLETELY WEATHERED	Throughout	-	Resembles a soil	Partially preserved	Complete separation. Easily indented with knife. Slakes

5. DISCONTNUITY SPACING

SEPARATION (mm)	SPACING (foliation, cleavage, bedding, etc.)	SPACING (bedding, etc.)
<6	Very intensely	Very highly fractured
6 - 20	Intensely	
20 - 60	Very thinly	Highly fractured
60 – 200	Thinly	
200 – 600	Medium	Moderately fractured
600 – 2000	Thickly	Slightly fractured
>2000	Very thickly	Very slightly fractured

6. DISCONTINUITY SURFACE DESCRIPTION:

6.1 JOINT FILLING

JOINT FILL TYPE	DEFINITATION (wall separation specified in mm)
CLEAN	No fracture filling
STAINED	Colouration of rock only. No recognizable filling material
FILLED	Fracture filled with finite thickness filling material

6. 2 DISCONTINUITY ORIENTATION

Discontinuity inclination (i.e. of joints, bedding, faults, etc.) are measured with respect to the horizontal i.e. a vertical joint dips at 90%. In oriented core the fracture inclinations are w.r.t. the core axis.

6.3 ROUGHNESS OF DISCONTINUITY PLANES

CLASSIFICATION	DESCRIPTION
SMOOTH	Appears smooth and is essentially smooth to the touch. May be slickensided
SLIGHTLY ROUGH	Asperities on the fracture surface are visible and can be distinctly felt
MEDIUM ROUGH	Asperities are clearly visible and fracture surface feels abrasive
ROUGH	Large angular asperities can be seen. Some ridge and high side angle steps evident
VERY ROUGH	Near vertical steps and ridges occur on the fracture surface

* Where slickensideds occur the direction of the slickensides should be recorded.

7. GRAIN SIZE

CLASSIFICATION	SIZE (mm)	RECOGNITION
VERY FINE GRAINED	<0.2	Individual grains cannot be seen with a hand lens
FINE GRAINED	0.2 – 0.6	Just visible as individual grains under hand lens
MEDIUM GRAINED	0.6 – 2	Grains clearly visible under hand lens, just visible to the naked eye
COARSE GRAINED	2 – 6	Grains clearly visible to the naked eye
VERY COARSE GRAINED	>6	Grains measurable

8. ROCK FORMATION
Brixton Formation, Halfway House Granite Dome Etc.

APPENDIX D:

PERCUSSION LOGS

APPENDIX D:

PERCUSSION LOGS

a) Substation
b) Wind Turbine Positions

APPENDIX D:

PERCUSSION LOGS

a) Substation

CLIENT:	**ESKOM**	
SITE:	**KOEKENAAP WESTERN CAPE**	
INVESTIGATION:	**SERE WIND ENERGY FACILITY SUBSTATION**	

BKS Palace Consortium

A

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 04	None	Good	
0 : 10	None	Good	
0 : 12	None	Good	
0 : 59	None	Good	
1 : 08	None	Good	5.0
3 : 22	None	Good	
0 : 43	None	Good	
0 : 51	None	Good	
1 : 05	None	Good	
0 : 58	None	Good	10.0
0 : 47	None	Good	
0 : 39	None	Good	
0 : 27	None	Good	
0 : 24	None	Good	
1 : 03	None	Good	15.0
0 : 30	None	Good	
0 : 20	None	Good	
0 : 19	None	Good	
0 : 20	None	Good	
0 : 22	None	Good	20.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange brown SAND. AEOLIAN.

SAND
Brown SAND. AEOLIAN.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225197
Machine:	Thor	Date drilled:	2010/03/08	y	6508714
Drilling operator:	Daniel	Recorded by:	Frank	z	58

CLIENT:	ESKOM	BKS Palace Consortium	B
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY SUBSTATION		SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 04	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 05	None	Good		
0 : 04	None	Good		
1 : 01	None	Good		**SAND** Brown SAND. AEOLIAN.
0 : 12	None	Good	5.0	
0 : 48	None	Good		
0 : 32	None	Good		**SAND** Reddish light brown SAND becoming yellowish with depth. AEOLIAN.
0 : 18	None	Good		
0 : 12	None	Good		
0 : 16	None	Good	10.0	
0 : 16	None	Good		
0 : 18	None	Good		
0 : 09	None	Good		
0 : 13	None	Good		
0 : 06	None	Good	15.0	
0 : 11	None	Good		
0 : 06	None	Good		
0 : 08	None	Good		
0 : 13	None	Good		
0 : 15	None	Good	20.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225252
Machine:	Thor	Date drilled:	2010/03/08	y	6508658
Drilling operator:	Daniel	Recorded by:	Frank	z	54

CLIENT:	ESKOM	BKS Palace Consortium
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY SUBSTATION	

C

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 08	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 07	None	Good		
0 : 14	None	Good		
0 : 45	None	Good		
0 : 48	None	Good	5.0	
1 : 07	None	Good		
0 : 40	None	Good		**SAND** Orange brown SAND. AEOLIAN.
0 : 30	None	Good		
0 : 24	None	Good		
0 : 7	None	Good	10.0	
0 : 07	None	Good		
0 : 07	None	Good		
0 : 16	None	Good		
0 : 21	None	Good		
0 : 15	None	Good	15.0	
0 : 13	None	Good		
0 : 13	None	Good		
0 : 15	None	Good		
0 : 13	None	Good		
0 : 10	None	Good	20.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225191
Machine:	Thor	Date drilled:	2010/03/08	y	6508608
Drilling operator:	Daniel	Recorded by:	Frank	z	56

CLIENT: **ESKOM**
SITE: **KOEKENAAP WESTERN CAPE**
INVESTIGATION: **SERE WIND ENERGY FACILITY SUBSTATION**

BKS Palace Consortium

D

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 07	None	Good	
0 : 11	None	Good	
0 : 14	None	Good	
0 : 18	None	Good	
1 : 17	None	Good	5.0
3 : 59	None	Good	
1 : 05	None	Good	
0 : 48	None	Good	
0 : 52	None	Good	
0 : 57	None	Good	10.0
0 : 48	None	Good	
0 : 32	None	Good	
0 : 28	None	Good	
0 : 27	None	Good	
0 : 25	None	Good	15.0
0 : 21	None	Good	
0 : 21	None	Good	
0 : 19	None	Good	
0 : 37	None	Good	
0 : 30	None	Good	20.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Brown SAND. AEOLIAN.

SAND
Orange brown SAND. AEOLIAN.

Profiled by: J Ehlers
Drilling Contractor: 121 Drilling
Machine: Thor
Drilling operator: Daniel

Compressor: 21 bar
Diameter: 6.5in
Date drilled: 2010/03/08
Recorded by: Frank

Coordinates
x 34 J 022539
y 6508654
z 58

APPENDIX D:

PERCUSSION LOGS

b) Wind Turbine Positions

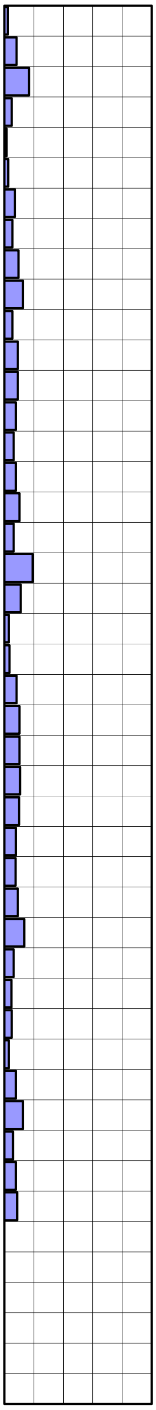
CLIENT:	**ESKOM**
SITE:	**KOEKENAAP WESTERN CAPE**
INVESTIGATION:	**SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 2

JOB. NO. J01386

SHEET 1 OF 1



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 21	None	Good	
0 : 42	None	Good	
0 : 13	None	Good	
0 : 04	None	Good	5.0
0 : 07	None	Good	
0 : 18	None	Good	
0 : 14	None	Good	
0 : 24	None	Good	
0 : 32	None	Good	10.0
0 : 14	None	Good	
0 : 23	None	Good	
0 : 23	None	Good	
0 : 20	None	Good	
0 : 16	None	Good	15.0
0 : 20	None	Good	
0 : 26	None	Good	
0 : 16	None	Good	
0 : 48	None	None	
0 : 28	None	Good	20.0
0 : 08	None	Good	
0 : 09	None	Good	
0 : 21	None	Good	
0 : 26	None	Good	
0 : 26	None	None	25.0
0 : 27	None	None	
0 : 25	None	None	
0 : 20	None	None	
0 : 19	None	Good	
0 : 23	None	Good	30.0
0 : 34	None	Good	
0 : 16	None	Good	
0 : 12	None	Good	
0 : 13	None	Good	
0 : 08	None	Good	35.0
0 : 20	None	Good	
0 : 32	None	None	
0 : 15	None	None	
0 : 20	None	None	
0 : 22	None	None	40.0

DESCRIPTION

SAND
Pale red brown SAND. AEOLIAN.

SAND
Brown SAND. AEOLIAN. Interpreted as ferruginized zone.

SAND
Yellow light brown SAND. MARINE. Interpreted as ferruginized zone.

NO SAMPLE
Interpreted as ferruginized SAND. PEDOGENIC.

SAND
Yellow brown SAND. MARINE.

NO SAMPLES
Interpreted as SAND. MARINE.

SAND
Yellow brown SAND. MARINE.

NO SAMPLES
Interpreted as SAND. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates		
Drilling Contractor:	121 Drilling	Diameter:	6.5in		x	34 J 0227156
Machine:	Thor	Date drilled:	28/07/2010		y	6504669
Drilling operator:	Daniel	Recorded by:	Frank		z	113

CLIENT:	ESKOM
SITE:	KOEKENAAP WESTERN CAPE
INVESTIGATION:	SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 6

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 09	None	Good	
0 : 18	None	Good	
2 : 44	None	Good	
3 : 08	None	Good	
0 : 28	None	Good	5.0
0 : 12	None	Good	
0 : 17	None	Good	
0 : 10	None	Good	
0 : 17	None	Good	
0 : 16	None	Good	10.0
0 : 19	None	Good	
0 : 26	None	Good	
0 : 12	None	Good	
0 : 18	None	Good	
0 : 14	None	Good	15.0
0 : 19	None	Good	
0 : 14	None	Good	
0 : 09	None	Good	
0 : 28	None	Good	
0 : 13	None	Good	20.0
0 : 10	None	Good	
0 : 16	None	Good	
0 : 13	None	Good	
0 : 14	None	Good	
0 : 20	None	Good	25.0
0 : 09	None	Good	
0 : 09	None	Good	
0 : 16	None	Good	
0 : 08	None	Good	
0 : 33	None	None	30.0
0 : 37	None	Good	
0 : 14	None	Good	
0 : 18	None	Good	
0 : 26	None	Good	
0 : 27	None	Good	35.0
3 : 15	None	Good	
2 : 41	None	Good	
3 : 12	None	Good	
4 : 05	None	Good	
1 : 48	None	Good	40.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Light orange brown SAND. AEOLIAN.

SAND
Yellowish brown SAND. AEOLIAN. Interpreted as ferruginized zone.

SAND
Light brown SAND. AEOLIAN.

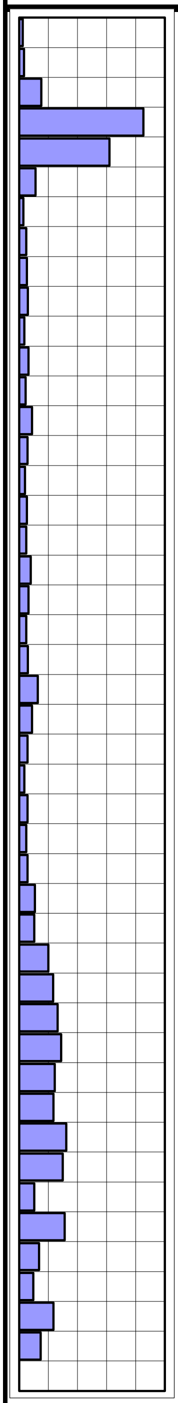
NO SAMPLE
Interpreted as moderately to slightly weathered hard to very hard quartzite COBBLE. MARINE.

SAND
Light brown SAND. MARINE.

SAND
Light brown SAND with traces of brown silty clay. Interpreted as RESIDUAL PHYLLITE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0226341
Machine:	Thor	Date drilled:	28/07/2010	y	6505567
Drilling operator:	Daniel	Recorded by:	Frank	z	70

CLIENT:	ESKOM	**BKS Palace Consortium**	**WTG 10**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 1 OF 2



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 08	None	Good	
0 : 38	None	Good	
3 : 33	None	Good	
2 : 35	None	Good	5.0
0 : 28	None	Good	
0 : 07	None	Good	
0 : 12	None	Good	
0 : 13	None	Good	
0 : 15	None	Good	10.0
0 : 09	None	Good	
0 : 16	None	Good	
0 : 11	None	Good	
0 : 22	None	Good	
0 : 14	None	Good	15.0
0 : 10	None	Good	
0 : 13	None	Good	
0 : 12	None	Good	
0 : 20	None	Good	
0 : 16	None	Good	20.0
0 : 12	None	Good	
0 : 15	None	Good	
0 : 32	None	Good	
0 : 22	None	Good	
0 : 14	None	Good	25.0
0 : 09	None	Good	
0 : 14	None	Good	
0 : 12	None	Good	
0 : 14	None	Good	
0 : 27	None	Good	30.0
0 : 26	None	Good	
0 : 50	None	Good	
0 : 58	None	Good	
1 : 06	None	Good	
1 : 12	None	Good	35.0
1 : 01	None	Good	
0 : 59	None	Good	
1 : 21	None	Good	
1 : 15	None	Good	
0 : 26	None	Good	40.0
1 : 18	None	Good	
0 : 34	None	Good	
0 : 24	None	Good	
0 : 59	None	Good	
0 : 37	None	Good	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Light brown SAND with minor-abundant white-grey angular hard slightly weathered quartz gravel. MARINE. (Possible cobble/boulder).

SILT
Light grey SILT with traces of grey and white angular hard slightly weathered quartz gravel (2-4mm). MARINE.

SILT
Light brown SILT with traces of white and grey hard angular slightly weathered quartz gravel (2-6mm chips). MARINE.

SILT
Dark grey SILT with traces of white and grey hard angular slightly weathered quartz gravel (2-6mm chips). MARINE.

SILT
Light brown SILT with traces of white and grey hard angular slightly weathered quartz gravel (2-6mm chips). MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225529
Machine:	Thor	Date drilled:	28/07/2010	y	6506469
Drilling operator:	Daniel	Recorded by:	Frank	z	60

CLIENT: ESKOM
SITE: KOEKENAAP WESTERN CAPE
INVESTIGATION: SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 10

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 39	None	Good	
0 : 40	None	Good	
0 : 35	None	Good	
0 : 17	None	Good	
0 : 19	None	Good	50.0
0 : 16	None	Good	
0 : 23	None	Good	
0 : 19	None	Good	
0 : 41	None	Good	54.0

DESCRIPTION

SILT
Light brown SILT with traces of white and grey hard angular slightly weathered quartz gravel (2-6mm chips). MARINE.

SANDY SILT
Light brown and yellow brown sandy SILT. MARINE.

FINE SAND
Light grey to light brown fine SAND. MARINE.

SILT
Grey SILT with traces of highly weathered soft subrounded phyllite chips (highly weathered Phyllite). Interpreted as RESIDUAL PHYLLITE.

Profiled by: J Ehlers
Drilling Contractor: 121 Drilling
Machine: Thor
Drilling operator: Daniel

Compressor: 21 bar
Diameter: 6.5in
Date drilled: 28/07/2010
Recorded by: Frank

Coordinates
x 34 J 0225529
y 6506469
z 60

CLIENT:	ESKOM	**BKS Palace Consortium**	**WTG 14**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 09	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 04	None	Good		
0 : 12	None	Good		
0 : 24	None	Good		
1 : 41	None	Good	5.0	
1 : 43	None	Good		
0 : 08	None	Good		**SAND** Orange SAND. AEOLIAN.
0 : 40	None	Good		
0 : 24	None	Good		
0 : 35	None	Good	10.0	
0 : 32	None	Good		
1 : 28	None	Good		**SAND** Light yellow SAND. AEOLIAN.
1 : 17	None	Good		
0 : 31	None	Good		
0 : 33	None	Good	15.0	
0 : 37	None	Good		
0 : 38	None	Good		
0 : 18	None	Good		
0 : 18	None	Good		
0 : 33	None	Good	20.0	
0 : 10	None	Good		
0 : 11	None	Good		
0 : 17	None	Good		
0 : 15	None	Good		
0 : 07	None	Good	25.0	
0 : 10	None	Good		
0 : 12	None	Good		
0 : 14	None	Good		
0 : 16	None	Good		
0 : 27	None	Good	30.0	
0 : 47	None	Good		
0 : 57	None	Good		
0 : 27	None	Good		
0 : 16	None	Good		
0 : 28	None	Good	35.0	
0 : 48	None	Good		
0 : 07	None	Good		
0 : 28	None	Good		
0 : 10	None	Good		
0 : 24	None	Good	40.0	
0 : 27	None	Good		
0 : 30	None	Good		
0 : 14	None	Good		
1 : 54	None	Good		
0 : 50		Good	45.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contract	121 Drilling	Diameter:	6.5in	x	34 J 0224704
Machine:	Thor	Date drilled:	27/07/2010	y	6507321
Drilling operator:	Daniel	Recorded by:	Frank	z	75

CLIENT:	ESKOM	BKS Palace Consortium
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 14

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
1 : 14	None	Good		**SAND** Light yellow SAND. AEOLIAN.
0 : 46	None	None		**NO SAMPLE RETURN** Interpreted as SAND. AEOLIAN.
0 : 34	None	None		
0 : 52	None	None		
0 : 56	None	None	50.0	
0 : 54	None	None		
1 : 21	None	None		
1 : 29	None	None		
1 : 00	None	None	54.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0224704
Machine:	Thor	Date drilled:	27/07/2010	y	6507321
Drilling operator:	Daniel	Recorded by:	Frank	z	75

CLIENT:	ESKOM	BKS Palace Consortium	WTG 18
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 08	None	Good	
0 : 10	None	Good	
0 : 31	None	Good	
0 : 33	None	Good	5.0
0 : 11	None	Good	
0 : 12	None	Good	
0 : 12	None	Good	
0 : 09	None	Good	
0 : 09	None	Good	10.0
0 : 09	None	Good	
0 : 12	None	Good	
0 : 09	None	Good	
0 : 12	None	Good	
0 : 12	None	Good	15.0
0 : 37	None	Good	
0 : 21	None	Good	
0 : 38	None	Good	
0 : 07	None	None	
0 : 41	None	Good	20.0
0 : 12	None	Good	
0 : 18	None	None	
0 : 13	None	None	
0 : 13	None	None	24.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Yellow brown SAND. AEOLIAN.

SAND
Brown SAND. AEOLIAN.

NO SAMPLE RETURN
Interpreted as SAND. AEOLIAN.

SAND
Brown SAND. AEOLIAN.

NO SAMPLE RETURN
Interpreted as SAND. AEOLIAN.

Note; depth 6m, interpreted as lenses of completely ferruginized sand.

Note; drilling terminated due to no samples return and collapsing of sidewalls.

Note; rock outcrop ~5m, eastern vicinity of drillhole.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223861
Machine:	Thor	Date drilled:	27/07/2010	y	6508223
Drilling operator:	Daniel	Recorded by:	Frank	z	65

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 20**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 03	None	Good	
0 : 09	None	Good	
0 : 12	None	Good	
0 : 33	None	Good	
1 : 02	None	Good	5.0
2 : 33	None	Good	
0 : 15	None	Good	
0 : 18	None	Good	
0 : 20	None	Good	
0 : 10	None	Good	10.0
0 : 17	None	Good	
0 : 11	None	Good	
0 : 13	None	Good	
0 : 20	None	Good	
0 : 30	None	Good	15.0
0 : 20	None	Good	
2 : 06	None	Good	
0 : 42	None	Good	
0 : 23	None	Good	
0 : 16	None	Good	20.0
0 : 16	None	Good	
0 : 12	None	Good	
0 : 16	None	Good	
0 : 48	None	Good	
0 : 38	None	Good	25.0
0 : 28	None	Good	
1 : 02	None	Good	27.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange brown SAND. AEOLIAN.

SAND
Reddish brown SAND. AEOLIAN.

SAND
Minor light brown SAND (2-15mm chips) of very weakly cemented sand (angular chips can be crumbled with ease by hand). MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223408
Machine:	Thor	Date drilled:	27/07/2010	y	6508885
Drilling operator:	Daniel	Recorded by:	Frank	z	70

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 22**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 09	None	Good		**SAND** Pale red sand. AEOLIAN.
0 : 07	None	Good		
0 : 09	None	Good		
0 : 09	None	Good		**SAND** Light yellow sand. AEOLIAN.
0 : 20	None	Good	5.0	
0 : 15	None	Good		
0 : 13	None	Good		
0 : 20	None	Good		
0 : 26	None	Good		
0 : 28	None	Good	10.0	
0 : 29	None	Good		
0 : 29	None	Good		
0 : 15	None	Good		
0 : 15	None	Good		
0 : 13	None	Good	15.0	
0 : 07	None	Good		**NO SAMPLE RETURN** Interpreted as sand. AEOLIAN?
0 : 09	None	None		
0 : 11	None	None	18.0	

Note; drilling terminated due to no samples return and collapsing of sidewalls.

Profiled by:	G Rabodiba	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0222951
Machine:	Thor	Date drilled:	26/07/2010	y	6509531
Drilling operator:	Daniel	Recorded by:	Frank	z	91

CLIENT:	**ESKOM**	
SITE:	**KOEKENAAP WESTERN CAPE**	
INVESTIGATION:	**SERE WIND ENERGY FACILITY**	

BKS Palace Consortium

WTG 24

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 05	None	Good	
0 : 15	None	Good	
0 : 26	None	Good	
0 : 13	None	Good	
0 : 21	None	Good	5.0
0 : 31	None	Good	
0 : 20	None	Good	
0 : 12	None	Good	
0 : 10	None	Good	
0 : 06	None	Good	10.0
0 : 03	None	Good	
0 : 03	None	Good	
0 : 22	None	Good	
0 : 18	None	Good	
0 : 56	None	Good	15.0
0 : 57	None	Good	
0 : 46	None	Good	
0 : 41	None	Good	18.0

DESCRIPTION
SAND Pale red SAND. AEOLIAN.
SAND Light brown SAND. MARINE.
SAND Light brown SAND with minor hard subangular fine quartz gravel. MARINE.
NO SAMPLE Interpreted as SAND with minor hard subangular fine quartz gravel. MARINE.
SAND Light brown SAND with minor hard subrounded fine quartz gravel. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates		
Drilling Contractor:	121 Drilling	Diameter:	6.5in		x	34 J 0222495
Machine:	Thor	Date drilled:	26/07/2010		y	6510190
Drilling operator:	Daniel	Recorded by:	Frank		z	97

CLIENT:	**ESKOM**	**BKS Palace Consortium**
SITE:	**KOEKENAAP WESTERN CAPE**	
INVESTIGATION:	**SERE WIND ENERGY FACILITY**	

WTG 25

JOB. NO. J01386

SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 25	None	Good	
0 : 27	None	Good	
0 : 10	None	Good	
0 : 23	None	Good	
0 : 11	None	Good	5.0
0 : 11	None	Good	
0 : 11	None	Good	
0 : 17	None	Good	
0 : 10	None	Good	
0 : 09	None	Good	10.0
0 : 09	None	Good	
0 : 07	None	Good	
0 : 11	None	Good	
0 : 10	None	Good	
0 : 08	None	Good	15.0
0 : 10	None	Good	
0 : 09	None	Good	
0 : 08	None	Good	
0 : 14	None	Good	
0 : 11	None	Good	20.0
0 : 08	None	Good	
0 : 10	None	Good	
0 : 07	None	Good	
0 : 09	None	Good	
0 : 08	None	Good	25.0
0 : 08	None	Good	
0 : 11	None	Good	
0 : 13	None	Good	
0 : 22	None	Good	
0 : 32	None	Good	30.0
0 : 20	None	Good	
0 : 41	None	Good	
0 : 44	None	Good	
0 : 31	None	Good	
0 : 15	None	Good	35.0
0 : 20	None	Good	
0 : 12	None	Good	
0 : 13	None	Good	
0 : 07	None	Good	
0 : 18	None	Good	40.0
0 : 06	None	Good	
0 : 13	None	Good	
0 : 18	None	Good	
0 : 11	None	Good	
0 : 08	None	Good	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Light brown SAND. MARINE.

SANDY SILT
Light brownish grey slightly sandy SILT with traces of hard grey quartz gravel (2-4mm). MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0222605
Machine:	Thor	Date drilled:	26/07/2010	y	6510997
Drilling operator	Daniel	Recorded by:	Frank	z	94

CLIENT:	ESKOM	BKS Palace Consortium
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILTY	

WTG 25

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 11	None	Good		**SANDY SILT** Light brownish grey slightly sandy SILT with traces of hard grey quartz gravel (2-4mm). MARINE.
0 : 31	None	Good		
0 : 21	None	Good		
0 : 19	None	Good		
0 : 06	None	Good	50.0	
0 : 09	None	Good		
0 : 08	None	Good		
0 : 07	None	Good		
0 : 34	None	Good	54.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0222605
Machine:	Thor	Date drilled:	26/07/2010	y	6510997
Drilling operator:	Daniel	Recorded by:	Frank	z	94

CLIENT: **ESKOM**
SITE: **KOEKENAAP WESTERN CAPE**
INVESTIGATIO: **SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 27

JOB. NO. J01386

SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 08	None	Good	
0 : 29	None	Good	
0 : 58	None	Good	
0 : 29	None	Good	
0 : 16	None	Good	5.0
0 : 59	None	Good	
0 : 44	None	Good	
0 : 32	None	Good	
0 : 45	None	Good	
0 : 49	None	Good	10.0
0 : 50	None	Good	
1 : 12	None	Good	
0 : 58	None	Good	
1 : 01	None	Good	
1 : 11	None	Good	15.0
1 : 07	None	Good	
1 : 04	None	Good	
1 : 23	None	Good	
1 : 06	None	Good	
0 : 52	None	Good	20.0
0 : 58	None	Good	
0 : 16	None	Good	
0 : 25	None	Good	
0 : 49	None	Good	
0 : 46	None	Good	25.0
0 : 54	None	Good	
0 : 52	None	Good	
0 : 46	None	Good	
1 : 09	None	Good	
1 : 42	None	Good	30.0
1 : 36	None	Good	
0 : 47	None	Good	
0 : 30	None	Good	
0 : 30	None	Good	
0 : 16	None	Good	35.0
0 : 17	None	Good	
0 : 17	None	Good	
0 : 18	None	Good	
0 : 34	None	Good	
0 : 22	None	Good	40.0
0 : 13	None	Good	
0 : 19	None	Good	
0 : 24	None	Good	
0 : 16	None	Good	
0 : 09	None	Good	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Reddish brown SAND with minor hard angular very weakly cemented reddish brown sand. AEOLIAN.

SILT
Light brown grey SILT with traces of grey hard subangular quartz gravel. MARINE.

SILTY SAND
Reddish brown silty SAND. MARINE.

SANDY SILT
Brownish grey sandy SILT. MARINE.

SILTY SAND
Brown silty SAND. MARINE.

SANDY SILT
Brownish grey sandy SILT. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223061
Machine:	Thor	Date drilled:	26/07/2010	y	6510427
Drilling operator:	Daniel	Recorded by:	Frank	z	95

CLIENT:	**ESKOM**	**BKS Palace Consortium**
SITE:	**KOEKENAAP WESTERN CAPE**	
INVESTIGATION:	**SERE WIND ENERGY FACILITY**	

WTG 27

JOB. NO. J01386

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 18	None	Good		**SANDY SILT**
1 : 11	None	Good		Brownish grey sandy SILT. MARINE.
0 : 26	None	Good		**SILTY SAND**
0 : 26	None	Good		Light brown silty SAND with light brown black red hard
0 : 36	None	Good	50.0	subangular phyllite gravel (2-12mm). Interpreted as
0 : 40	None	Good		RESIDUAL PHYLLITE.
0 : 18	None	Good		
0 : 32	None	Good		
0 : 16	None	Good	54.0	

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates	
Drilling Contractor	121 Drilling	Diameter	6.5in	x	34 J 0223061
Machine	Thor	Date drilled	26/07/2010	y	6510427
Drilling operator	Daniel	Recorded by:	Frank	z	95

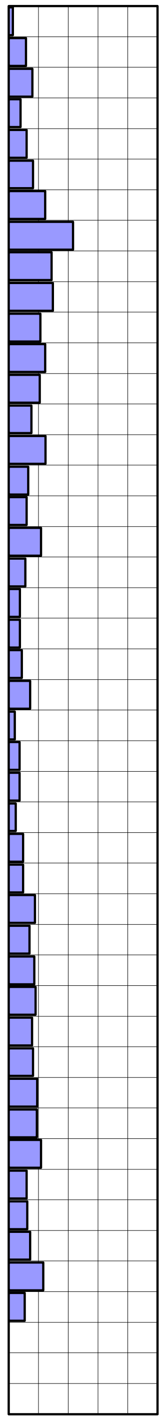
CLIENT:	ESKOM	
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

BKS Palace Consortium

WTG 29

JOB. NO. J01386

SHEET 1 OF 2



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 07	None	Good	
0 : 29	None	Good	
0 : 40	None	Good	
0 : 20	None	Good	
0 : 30	None	Good	5.0
0 : 41	None	Good	
1 : 01	None	Good	
1 : 48	None	Good	
1 : 12	None	Good	
1 : 14	None	Good	10.0
0 : 53	None	Good	
1 : 01	None	Good	
0 : 52	None	Good	
0 : 38	None	Good	
1 : 02	None	Good	15.0
0 : 33	None	Good	
0 : 30	None	Good	
0 : 54	None	Good	
0 : 28	None	Good	
0 : 19	None	Good	20.0
0 : 19	None	Good	
0 : 22	None	Good	
0 : 36	None	Good	
0 : 10	None	Good	
0 : 18	None	Good	25.0
0 : 18	None	Good	
0 : 12	None	Good	
0 : 24	None	Good	
0 : 24	None	Good	
0 : 44	None	Good	30.0
0 : 35	None	Good	
0 : 43	None	Good	
0 : 45	None	Good	
0 : 39	None	Good	
0 : 41	None	Good	35.0
0 : 48	None	Good	
0 : 47	None	Good	
0 : 54	None	Good	
0 : 30	None	Good	
0 : 31	None	Good	40.0
0 : 36	None	Good	
0 : 58	None	Good	
0 : 27	None	Good	

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Reddish orange SAND. AEOLIAN.

SANDY SILT
Orange grey (light yellow at 15-16m) sandy SILT. MARINE.

SAND
Light brownish white SAND with minor light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as RESIDUAL QUARTZITE.

SAND
Light brownish white SAND with traces of light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as RESIDUAL QUARTZITE.

QUARTZITE
Light brownish white SAND with minor light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as QUARTZITE BEDROCK.

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates		
Drilling Contractor	121 Drilling	Diameter	6.5in		x	34 J 0223539
Machine	Thor	Date drilled	26/07/2010		y	6510181
Drilling operator	Daniel	Recorded by:	Frank		z	88

CLIENT:	ESKOM	BKS Palace Consortium	WTG 29
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND FARM ENERGY FACILITY		

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 41	None	Good	
0 : 42	None	Good	45.0
0 : 32	None	Good	
0 : 21	None	Good	
0 : 20	None	Good	
0 : 21	None	Good	
0 : 18	None	Good	50.0
0 : 22	None	Good	
0 : 47	None	Good	
0 : 57	None	Good	
1 : 16	None	Good	

DESCRIPTION

QUARTZITE
Light brownish white SAND with traces of light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as QUARTZITE BEDROCK.

QUARTZITE
Reddish brown SAND with traces-minor fine quartz gravel. Interpreted as QUARTZITE BEDROCK.

QUARTZITE
Light brownish white SAND with minor light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as QUARTZITE BEDROCK.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates		
Drilling Contractor:	121 Drilling	Diameter:	6.5in		x	34 J 0223539
Machine:	Thor	Date drilled:	26/07/2010		y	6510181
Drilling operator:	Daniel	Recorded by:	Frank		z	88

CLIENT:	ESKOM
SITE:	KOEKENAAP WESTERN CAPE
INVESTIGATION:	SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 31

JOB. NO. J01386

SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 03	None	Good	
0 : 05	None	Good	
0 : 33	None	Good	
0 : 28	None	Good	
0 : 14	None	Good	5.0
0 : 23	None	Good	
0 : 23	None	Good	
0 : 16	None	Good	
0 : 18	None	Good	
0 : 42	None	Good	10.0
0 : 38	None	Good	
0 : 38	None	Good	
1 : 13	None	Good	
1 : 46	None	Good	
2 : 36	None	Good	15.0
1 : 16	None	Good	
0 : 59	None	Good	
0 : 38	None	Good	
0 : 48	None	Good	
0 : 12	None	Good	20.0
0 : 11	None	Good	
2 : 42	None	Good	
1 : 28	None	Good	
0 : 48	None	Good	
0 : 48	None	Good	25.0
0 : 24	None	Good	
0 : 20	None	Good	
0 : 38	None	Good	
0 : 29	None	Good	
0 : 39	None	Good	30.0
0 : 38	None	Good	
0 : 32	None	Good	
0 : 33	None	Good	
0 : 28	None	Good	
0 : 31	None	Good	35.0
0 : 41	None	Good	
0 : 18	None	Good	
0 : 19	None	Good	
0 : 39	None	Good	
0 : 32	None	Good	40.0
0 : 42	None	Good	
0 : 40	None	Good	
0 : 49	None	Good	
0 : 36	None	Good	
0 : 31	None	Good	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Reddish orange SAND. AEOLIAN.

SAND
Light brown SAND with traces of rounded quartz gravel. MARINE.

SILT
Light grey SILT. MARINE.

SANDY SILT
Yellowish grey slightly sandy SILT. MARINE. (Possible contamination from sand).

SANDY SILT
Brownish white sandy SILT with minor light brown hard subangular fine to medium slightly weathered quartz gravel. MARINE.

QUARTZITE
Brownish white sandy SILT with traces of light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as QUARTZITE BEDROCK.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0224029
Machine:	Thor	Date drilled:	26/07/2010	y	6509871
Drilling operator:	Daniel	Recorded by:	Frank	z	68

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 31**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 42	None	Good		**QUARTZITE** Brownish white sandy SILT with traces of light brown hard subangular fine to medium slightly weathered quartz gravel. Interpreted as QUARTZITE BEDROCK.
0 : 33	None	Good		
0 : 38	None	Good		
0 : 29	None	Good		
0 : 50	None	Good	50.0	
0 : 16	None	Good		
0 : 16	None	Good		
0 : 14	None	Good		
0 : 14	None	Good	54.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0224029
Machine:	Thor	Date drilled:	26/07/2010	y	6509871
Drilling operator:	Daniel	Recorded by:	Frank	z	68

CLIENT:	ESKOM
SITE:	KOEKENAAP WESTERN CAPE
INVESTIGATION:	SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 33

JOB. NO. J01386

SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 06	None	Good	
0 : 53	None	Good	
1 : 20	None	Good	
0 : 55	None	Good	5.0
1 : 02	None	Good	
0 : 15	None	Good	
0 : 24	None	Good	
0 : 30	None	Good	
0 : 34	None	Good	10.0
0 : 29	None	Good	
0 : 30	None	Good	
0 : 28	None	Good	
0 : 28	None	Good	
0 : 30	None	Good	15.0
0 : 31	None	Good	
0 : 09	None	Good	
0 : 57	None	Good	
0 : 12	None	Good	
0 : 12	None	Good	20.0
0 : 13	None	Good	
0 : 17	None	Good	
0 : 13	None	Good	
0 : 19	None	Good	
0 : 12	None	Good	25.0
0 : 28	None	Good	
0 : 27	None	Good	
0 : 20	None	Good	
0 : 20	None	Good	
0 : 21	None	Good	30.0
0 : 06	None	Good	
0 : 08	None	None	
0 : 15	None	None	
0 : 18	None	None	
0 : 09	None	None	35.0
0 : 08	None	None	
0 : 10	None	Good	
0 : 11	None	Good	
0 : 18	None	Good	
2 : 10	None	Good	40.0
0 : 03	None	None	
0 : 11	None	None	
2 : 27	None	None	
0 : 57	None	None	
0 : 04	None	None	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange brown SAND. AEOLIAN.

SAND
Orange light brown SAND. AEOLIAN.

SAND
Yellow brown SAND. AEOLIAN.

NO SAMPLE RETURN
Interpreted as SAND. AEOLIAN.

SAND
Yellow brown SAND. AEOLIAN.

NO SAMPLE RETURN
Interpreted as SAND. AEOLIAN?

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225119
Machine:	Thor	Date drilled:	22/07/2010	y	6509316
Drilling operator:	Daniel	Recorded by:	Frank	z	59

CLIENT:	ESKOM	**BKS Palace Consortium**
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 33

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)		DESCRIPTION
0 : 07	None	None			**NO SAMPLE RETURN**
0 : 37	None	None	47.0		Interpreted as SAND. AEOLIAN?

Note; Drillrods stuck in hole from 15 to 45m below top of borehole.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225119
Machine:	Thor	Date drilled:	22/07/2010	y	6509316
Drilling operator:	Daniel	Recorded by:	Frank	z	59

CLIENT:	ESKOM	**BKS Palace Consortium**
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 35

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 06	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 06	None	Good		
0 : 04	None	Good		
0 : 03	None	Good		
0 : 03	None	Good	5.0	
0 : 03	None	Good		
0 : 34	None	Good		**SAND** Orange brown becoming more orange with depth SAND. AEOLIAN.
0 : 36	None	Good		
1 : 04	None	Good		
1 : 08	None	Good	10.0	
0 : 59	None	Good		
0 : 36	None	Good		
0 : 37	None	Good		
0 : 36	None	Good		
0 : 09	None	Good	15.0	
0 : 12	None	Good		
0 : 12	None	Good		
0 : 08	None	Good		
0 : 13	None	Good		
0 : 11	None	Good	20.0	
0 : 05	None	Good		
0 : 04	None	Good		
0 : 03	None	Good		
0 : 09	None	Good		
0 : 10	None	Good	25.0	**SAND** Yellow orange SAND. AEOLIAN.
0 : 08	None	Good		
0 : 21	None	Good		
0 : 06	None	Good		
0 : 38	None	Good		
0 : 46	None	Good	30.0	
0 : 20	None	Good		
0 : 12	None	Good		
1 : 04	None	Good		
2 : 26	None	Good		
1 : 03	None	Good	35.0	
2 : 35	None	Good		
0 : 45	None	Good		
0 : 48	None	Good		
0 : 53	None	Good		
0 : 44	None	Good	40.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0226202
Machine:	Thor	Date drilled:	31/07/2010	y	6509006
Drilling operator:	Daniel	Recorded by:	Frank	z	59

CLIENT:	ESKOM	BKS Palace Consortium
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 37

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 06	None	Good	
0 : 06	None	Good	
0 : 21	None	Good	
0 : 10	None	Good	5.0
0 : 17	None	Good	
0 : 11	None	Good	
0 : 14	None	Good	
0 : 19	None	Good	
0 : 14	None	Good	10.0
0 : 18	None	Good	
0 : 18	None	Good	
0 : 20	None	Good	
0 : 18	None	Good	
0 : 17	None	Good	15.0
0 : 28	None	Good	
0 : 25	None	Good	
0 : 19	None	Good	
0 : 15	None	Good	
0 : 13	None	Good	20.0
0 : 11	None	Good	
0 : 15	None	Good	
0 : 16	None	Good	
0 : 13	None	Good	
0 : 19	None	Good	25.0
0 : 09	None	Good	
0 : 10	None	Good	
0 : 15	None	Good	
0 : 16	None	Good	
0 : 27	None	Good	30.0
0 : 26	None	Good	
0 : 28	None	Good	
0 : 21	None	Good	
0 : 22	None	Good	
0 : 21	None	Good	35.0
0 : 46	None	Good	
0 : 33	None	Good	
0 : 30	None	Good	
0 : 29	None	Good	
0 : 18	None	Good	40.0

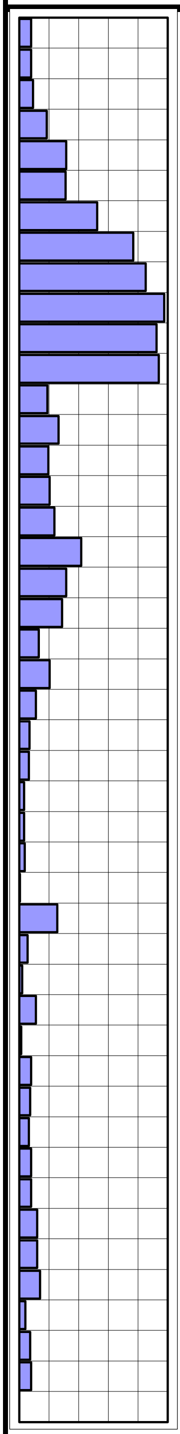
DESCRIPTION

SAND
Pale red sand. AEOLIAN.

SILT
Light grey to white SILT with traces of grey slightly weathered quartz gravel. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0227590
Machine:	Thor	Date drilled:	2010/02/08	y	6508606
Drilling operator:	Daniel	Recorded by:	Frank	z	53

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 39**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 1 OF 3



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 20	None	Good	
0 : 20	None	Good	
0 : 23	None	Good	
0 : 46	None	Good	
1 : 19	None	Good	5.0
1 : 18	None	Good	
2 : 11	None	Good	
3 : 12	None	Good	
3 : 33	None	Good	
4 : 04	None	Good	10.0
3 : 51	None	Good	
3 : 55	None	Good	
0 : 47	None	Good	
1 : 06	None	Good	
0 : 49	None	Good	15.0
0 : 51	None	Good	
0 : 59	None	Good	
1 : 44	None	Good	
1 : 19	None	Good	
1 : 12	None	Good	20.0
0 : 33	None	Good	
0 : 51	None	Good	
0 : 28	None	Good	
0 : 17	None	Good	
0 : 16	None	Good	25.0
0 : 08	None	Good	
0 : 08	None	Good	
0 : 09	None	Good	
0 : 01	None	Good	
1 : 04	None	Good	30.0
0 : 14	None	Good	
0 : 05	None	Good	
0 : 28	None	Good	
0 : 03	None	Good	
0 : 20	None	Good	35.0
0 : 18	None	Good	
0 : 16	None	Good	
0 : 20	None	Good	
0 : 20	None	Good	
0 : 30	None	Good	40.0
0 : 30	None	Good	
0 : 35	None	Good	
0 : 10	None	Good	
0 : 18	None	Good	
0 : 20	None	Good	45.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Reddish yellowish orange SAND with medium sized chips 2mm of cemented orange sand. AEOLIAN.

SILTY SAND
Orange red slightly silty SAND. AEOLIAN.

SAND
Reddish yellow orange SAND. AEOLIAN.

SAND
Light brown SAND with minor brown to grey highly weathered angular quartz gravel (2-8mm). MARINE.

FINE SAND
Brown fine SAND with traces of brown to grey highly weathered angular quartz gravel (2-8mm). MARINE.

CLAYEY SANDY SILT
Greyish brown slightly micaceous clayey sandy SILT. Interpreted as RESIDUAL PHYLLITE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223029
Machine:	Thor	Date drilled:	20/07/2010	y	6512317
Drilling operator:	Daniel	Recorded by:	Frank	z	76

CLIENT:	ESKOM
SITE:	KOEKENAAP WESTERN CAPE
INVESTIGATION:	SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 39

JOB. NO. J01386

SHEET 2 OF 3

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 15	None	Good	
0 : 36	None	Good	
0 : 19	None	None	
0 : 33	None	Good	
0 : 55	None	Good	50.0
1 : 01	None	Good	
0 : 56	None	Good	
1 : 25	None	Good	
1 : 24	None	Good	
1 : 24	None	Good	55.0
0 : 41	None	Good	
1 : 04	None	Good	
1 : 02	None	Good	
0 : 42	None	Good	
0 : 45	None	Good	60.0
0 : 32	None	Good	
0 : 15	None	Good	
0 : 15	None	Good	
0 : 14	None	Good	
0 : 46	None	Good	65.0
0 : 38	None	Good	
0 : 23	None	Good	
0 : 30	None	Good	
0 : 28	None	Good	
0 : 35	None	Good	70.0
0 : 35	None	Good	
0 : 57	None	Good	
0 : 32	None	Good	
0 : 39	None	Good	
0 : 34	None	Good	75.0
0 : 33	None	Good	
0 : 27	None	Good	
0 : 45	None	Good	
1 : 13	None	Good	
0 : 49	None	Good	80.0
1 : 04	None	Good	
1 : 01	None	Good	
1 : 00	None	Good	
1 : 06	None	None	
0 : 52	None	None	85.0
1 : 01	None	None	
0 : 48	None	None	
1 : 08	None	None	
2 : 02	None	None	
0 : 48	None	None	90.0

DESCRIPTION

CLAYEY SANDY SILT
Greyish brown slightly micaceous clayey sandy SILT. Interpreted as RESIDUAL PHYLLITE.

CLAYEY SANDY SILT
Dark brown slightly micaceous clayey sandy SILT. Interpreted as RESIDUAL PHYLLITE.

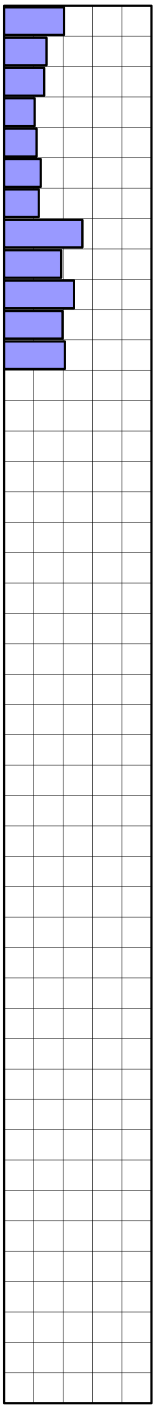
SILTY FINE SAND
Light brown silty fine SAND. Interpreted as RESIDUAL PHYLLITE.

CLAYEY SANDY SILT
Greyish brown slightly micaceous clayey sandy SILT with subrangular quartz chips (grey). Interpreted as RESIDUAL PHYLLITE.

NO SAMPLES
Interpreted as RESIDUAL PHYLLITE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223029
Machine:	Thor	Date drilled:	20/07/2010	y	6512317
Drilling operator:	Daniel	Recorded by:	Frank	z	76

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 39**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 3 OF 3



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
1 : 42	None	None		**NO SAMPLES** Interpreted as RESIDUAL PHYLLITE.
1 : 12	None	None		
1 : 08	None	None		
0 : 52	None	None		
0 : 55	None	None	95.0	
1 : 02	None	None		
0 : 59	None	None		
2 : 13	None	None		
1 : 37	None	None		
1 : 59	None	None	100.0	
1 : 39	None	None		
1 : 43	None	None	102.0	

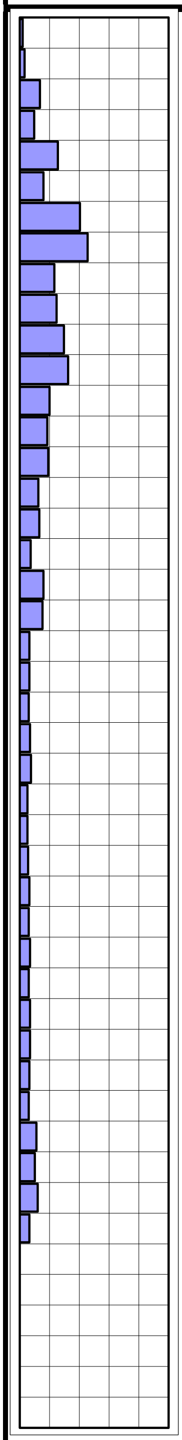
Note; water struck at 72m.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223029
Machine:	Thor	Date drilled:	20/07/2010	y	6512317
Drilling operator:	Daniel	Recorded by:	Frank	z	76

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 40**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 1 OF 1



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 05	None	Good	
0 : 08	None	Good	
0 : 34	None	Good	
0 : 24	None	Good	
1 : 04	None	Good	5.0
0 : 40	None	Good	
1 : 41	None	Good	
1 : 54	None	Good	
0 : 58	None	Good	
1 : 02	None	Good	10.0
1 : 14	None	Good	
1 : 21	None	Good	
0 : 50	None	Good	
0 : 46	None	Good	
0 : 48	None	Good	15.0
0 : 31	None	Good	
0 : 33	None	Good	
0 : 18	None	Good	
0 : 40	None	Good	
0 : 38	None	Good	20.0
0 : 16	None	Good	
0 : 16	None	Good	
0 : 15	None	Good	
0 : 17	None	Good	
0 : 19	None	Good	25.0
0 : 13	None	Good	
0 : 13	None	Good	
0 : 14	None	Good	
0 : 16	None	Good	
0 : 15	None	Good	30.0
0 : 17	None	Good	
0 : 15	None	Good	
0 : 17	None	Good	
0 : 17	None	Good	
0 : 16	None	Good	35.0
0 : 15	None	Good	
0 : 28	None	Good	
0 : 25	None	Good	
0 : 30	None	Good	
0 : 16	None	Good	40.0

DESCRIPTION

CLAYEY SAND
Pale red clayey SAND. AEOLIAN.

SAND
Orange SAND. AEOLIAN.

SAND
Red becoming orange with depth SAND. AEOLIAN.

SAND
Orange SAND. AEOLIAN.

SAND
Brown SAND with traces of black hard ferricrete nodules. PEDOGENIC.

SAND AND SILT
Yellow orange SAND and white SILT. MARINE.

SILTY SAND
Orange becoming white silty SAND. MARINE.

SILTY SAND
Orange mottled yellow and grey silty SAND with fine subangular sandstone gravel. MARINE.

SILTY SAND
Orange and white silty SAND. MARINE.

SANDY SILT
White sandy SILT with minor rounded quartz gravel. MARINE.

SILTY SAND
White silty SAND. MARINE.

SILY SAND
Orange to yellow and grey silty SAND with fine sub-angular calcrete gravel. MARINE.

SILT
Reddish grey and yellow SILT with traces of fine to medium subrounded quartz gravel. Interpreted RESIDUAL PHYLLITE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223340
Machine:	Thor	Date drilled:	2010/02/08	y	6512212
Drilling operator:	Daniel	Recorded by:	Frank	z	73

CLIENT:	ESKOM
SITE:	KOEKENAAP WESTERN CAPE
INVESTIGATION:	SERE WIND ENERGY FACILITY

BKS Palace Consortium

WTG 41

JOB. NO. J01386

SHEET 1 OF 3

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
1 : 03	None	Good	
1 : 24	None	Good	
1 : 26	None	Good	
1 : 24	None	Good	
1 : 09	None	Good	5.0
1 : 09	None	Good	
0 : 51	None	Good	
0 : 58	None	Good	
0 : 58	None	Good	
0 : 55	None	Good	10.0
0 : 50	None	Good	
0 : 52	None	Good	
0 : 50	None	Good	
0 : 41	None	Good	
0 : 24	None	Good	15.0
0 : 20	None	Good	
0 : 12	None	Good	
0 : 15	None	Good	
0 : 14	None	Good	
0 : 09	None	Good	20.0
0 : 26	None	Good	
0 : 09	None	Good	
0 : 08	None	Good	
0 : 10	None	Good	
0 : 10	None	Good	25.0
0 : 14	None	Good	
0 : 12	None	Good	
0 : 11	None	Good	
0 : 07	None	Good	
0 : 15	None	Good	30.0
1 : 04	None	Good	
1 : 08	None	Good	
1 : 50	None	Good	
2 : 48	None	Good	
0 : 43	None	Good	35.0
1 : 27	None	Good	
1 : 09	None	Good	
1 : 09	None	Good	
1 : 19	None	Good	
0 : 50	None	Good	40.0
1 : 16	None	Good	
1 : 45	None	Good	42.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange borwn SAND. AEOLIAN.

SAND
Yellowish brown SAND. MARINE.

SAND
Light brown SAND. MARINE.

QUARTZITE
Light brown SAND with minor fine subangular slightly weathered quartz gravel (2-5mm). Interpreted as weathered QUARTZITE.

QUARTZITE
Light grey SAND with abundant grey hard subangular quartz gravel (2-10mm). Interpreted as QUARTZITE BEDROCK.

QUARTZITE
Yellow brown SAND with traces of grey hard subangular weathered quartz gravel (2-5mm). Interpreted as weathered zone in QUARTZITE BEDROCK with slight contamination.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223834
Machine:	Thor	Date drilled:	20/07/2010	y	6511989
Drilling operator:	Daniel	Recorded by:	Frank	z	73

CLIENT: **ESKOM**
SITE: **KOEKENAAP WESTERN CAPE**
INVESTIGATION: **SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 41

JOB. NO. J01386

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
1 : 34	None	Good	
0 : 59	None	Good	
1 : 11	None	Good	45.0
1 : 38	None	Good	
0 : 56	None	Good	
1 : 17	None	Good	
1 : 28	None	Good	
1 : 24	None	Good	50.0
1 : 24	None	Good	
1 : 11	None	Good	
1 : 20	None	Good	
1 : 37	None	Good	
1 : 37	None	Good	55.0
1 : 28	None	Good	
1 : 55	None	Good	
1 : 28	None	Good	
1 : 27	None	Good	
1 : 32	None	Good	60.0
1 : 46	None	Good	
1 : 09	None	Good	
1 : 33	None	Good	
1 : 32	None	Good	
1 : 32	None	Good	65.0
1 : 36	None	Good	
1 : 20	None	Good	
0 : 50	None	Good	
1 : 04	None	Good	
1 : 06	None	Good	70.0
1 : 05	None	None	
1 : 05	None	None	
1 : 48	None	None	
1 : 48	None	None	
1 : 54	None	None	75.0
1 : 54	None	None	
1 : 27	None	None	
1 : 29	None	None	
1 : 52	None	None	
1 : 55	None	None	80.0
2 : 12	None	None	
2 : 12	None	None	
1 : 35	None	None	
2 : 39	None	None	
1 : 43	None	None	85.0
1 : 42	None	None	
2 : 06	None	None	

DESCRIPTION

QUARTZITE
Light grey SAND with abundant grey hard subangular quartz gravel (2-10mm). Interpreted as QUARTZITE BEDROCK.

QUARTZITE
Yellow brown SAND with traces of grey hard subangular weathered quartz gravel (2-5mm). Interpreted as QUARTZITE BEDROCK with slight contamination.

QUARTZITE
Brown SAND with white hard angular slightly weathered quartz gravel. Interpreted QUARTZITE BEDROCK.

NO SAMPLES
Interpreted as QUARTZITE BEDROCK.

Profiled by: J Ehlers
Drilling Contractor: 121 Drilling
Machine: Thor
Drilling operator: Daniel

Compressor: 21 bar
Diameter: 6.5in
Date drilled: 20/07/2010
Recorded by: Frank

Coordinates
x 34 J 0223834
y 6511989
z 73

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 41**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 3 OF 3

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
2 : 00	None	None		**NO SAMPLES** Interpreted as QUARTZITE BEDROCK.
1 : 50	None	None		
1 : 46	None	None	90.0	
0 : 49	None	None		
1 : 14	None	None		
1 : 37	None	None		
1 : 50	None	None		
1 : 06	None	None	95.0	
1 : 51	None	None		
2 : 38	None	None		
3 : 03	None	None		
2 : 06	None	None		
2 : 49	None	None	100.0	
2 : 26	None	None		
2 : 52	None	None	102.0	

Note; water struck at 69m.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0223834
Machine:	Thor	Date drilled:	20/07/2010	y	6511989
Drilling operator:	Daniel	Recorded by:	Frank	z	73

CLIENT:	ESKOM	**BKS Palace Consortium**	**WTG 42**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 06	None	Good	
0 : 06	None	Good	
0 : 08	None	Good	
0 : 30	None	Good	
0 : 32	None	Good	5.0
1 : 22	None	Good	
1 : 15	None	Good	
0 : 59	None	Good	
0 : 31	None	Good	
0 : 29	None	Good	10.0
0 : 22	None	Good	
0 : 11	None	Good	
0 : 28	None	Good	
0 : 23	None	Good	
0 : 16	None	Good	15.0
0 : 15	None	Good	
0 : 11	None	Good	
0 : 12	None	Good	
0 : 23	None	Good	
0 : 25	None	Good	20.0
0 : 21	None	Good	
0 : 14	None	Good	
0 : 10	None	Good	
0 : 09	None	Good	
0 : 22	None	Good	25.0
0 : 19	None	Good	
0 : 27	None	Good	
0 : 13	None	Good	
0 : 17	None	Good	
0 : 08	None	Good	30.0
0 : 42	None	Good	
0 : 38	None	Good	
0 : 23	None	Good	
0 : 28	None	Good	
0 : 39	None	Good	35.0
0 : 11	None	Good	
0 : 17	None	Good	
1 : 49	None	Good	
0 : 21	None	Good	
2 : 32	None	Good	40.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange to yellow SAND. AEOLIAN.

SAND
Orange red SAND. AEOLIAN.

SILTY SAND
Orange silty SAND. MARINE.

SAND
White orange yellow SAND with fine rounded quartz gravel. MARINE.

SILTY SAND
White silty SAND. MARINE.

SAND
Yellow SAND. MARINE.

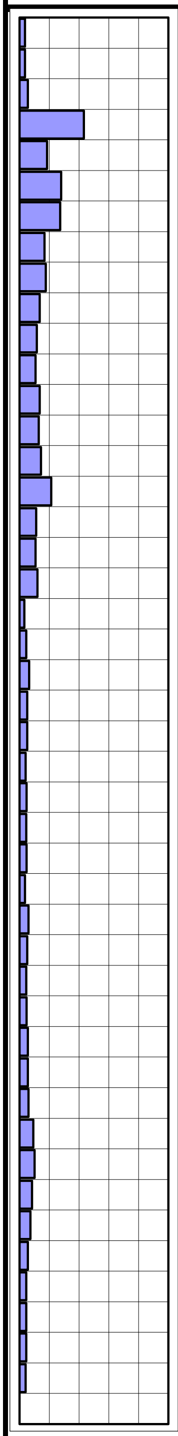
SILTY SAND
White silty SAND. MARINE.

SAND
White to grey tending orange with depth SAND and fine rounded quartz gravel. MARINE.

SANDY SILT
White blotched orange sandy SILT. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0224287
Machine:	Thor	Date drilled:	2010/02/08	y	6511470
Drilling operator:	Daniel	Recorded by:	Frank	z	74

CLIENT:	**ESKOM**	**BKS Palace Consortium**	**WTG 43**
SITE:	**KOEKENAAP WESTERN CAPE**		JOB. NO. J01386
INVESTIGATION:	**SERE WIND ENERGY FACILITY**		SHEET 1 OF 3



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 09	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 09	None	Good		
0 : 14	None	Good		**SAND** Orange brown to reddish ligh brown SAND with traces of orange brown weakly cemented sand (<3mm chips). AEOLIAN.
1 : 48	None	Good		
0 : 46	None	Good	5.0	
1 : 10	None	Good		
1 : 08	None	Good		
0 : 42	None	Good		
0 : 44	None	Good		
0 : 34	None	Good	10.0	
0 : 29	None	Good		**SAND** Light orange brown SAND with traces of black hard ferricrete nodules (<5mm). MARINE.
0 : 27	None	Good		
0 : 34	None	Good		
0 : 32	None	Good		
0 : 36	None	Good	15.0	
0 : 53	None	Good		**SAND** Orange light brown SAND with traces of grey slightly weathered quartz gravel (<5mm). MARINE.
0 : 28	None	Good		
0 : 27	None	Good		
0 : 30	None	Good		
0 : 08	None	Good	20.0	**SAND** Whitish light brown SAND. MARINE.
0 : 11	None	Good		
0 : 16	None	Good		
0 : 13	None	Good		
0 : 13	None	Good		
0 : 10	None	Good	25.0	
0 : 12	None	Good		
0 : 11	None	Good		
0 : 12	None	Good		
0 : 09	None	Good		
0 : 15	None	Good	30.0	
0 : 13	None	Good		
0 : 11	None	Good		
0 : 12	None	Good		**FINE SAND** Whitish grey very fine SAND. MARINE.
0 : 14	None	Good		
0 : 14	None	Good	35.0	
0 : 15	None	Good		
0 : 23	None	Good		
0 : 25	None	Good		
0 : 21	None	Good		
0 : 18	None	Good	40.0	
0 : 14	None	Good		
0 : 11	None	Good		
0 : 11	None	Good		
0 : 11	None	Good		
0 : 10	None	Good	45.0	

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter	6.5in	x	34 J 0224645
Machine:	Thor	Date drilled	21/07/2010	y	6511291
Drilling operator:	Daniel	Recorded by:	Frank	z	74

CLIENT: **ESKOM**
SITE: **KOEKENAAP WESTERN CAPE**
INVESTIGATION: **SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 43

JOB. NO. J01386

SHEET 2 OF 3

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 12	None	Good	
0 : 09	None	Good	
0 : 07	None	Good	
0 : 20	None	Good	
0 : 24	None	Good	50.0
0 : 33	None	Good	
1 : 38	None	Good	
0 : 32	None	Good	
0 : 50	None	Good	
0 : 28	None	Good	55.0
0 : 28	None	Good	
0 : 36	None	Good	
0 : 23	None	Good	
0 : 21	None	Good	
0 : 33	None	Good	60.0
0 : 53	None	Good	
0 : 40	None	Good	
0 : 46	None	Good	
1 : 07	None	Good	
0 : 40	None	Good	65.0
0 : 46	None	Good	
0 : 55	None	Good	
0 : 52	None	Good	
0 : 36	None	Good	
0 : 56	None	Good	70.0
0 : 49	None	Good	
0 : 55	None	Good	
1 : 02	None	None	
1 : 02	None	None	
1 : 07	None	Good	75.0
1 : 07	None	Good	
1 : 13	None	Good	
1 : 32	None	Good	
1 : 03	None	None	
1 : 51	None	None	80.0
1 : 14	None	None	
1 : 15	None	None	
1 : 33	None	None	
1 : 12	None	None	
2 : 13	None	None	85.0
2 : 10	None	None	
1 : 13	None	None	
1 : 36	None	None	
1 : 48	None	None	
1 : 41	None	None	90.0

DESCRIPTION

FINE SAND
Whitish grey very fine SAND. MARINE.

FINE SAND
Light grey brown fine SAND. MARINE.

SILT
Dark and grey slightly micaceous SILT. Interpreted as RESIDUAL PHYLLITE.

NO SAMPLES
Interpreted as RESIDUAL PHYLLITE.

FINE SAND
Light grey brown fine SAND. Interpreted as RESIDUAL PHYLLITE.

NO SAMPLES
Interpreted as RESIDUAL PHYLLITE.

Profiled by: J Ehlers
Drilling Contractor: 121 Drilling
Machine: Thor
Drilling operator: Daniel

Compressor: 21 bar
Diameter: 6.5in
Date drilled: 21/07/2010
Recorded by: Frank

Coordinates
x 34 J 0224645
y 6511291
z 74

CLIENT:	ESKOM	BKS Palace Consortium
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 43

JOB. NO. J01386

SHEET 3 OF 3

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
1 : 36	None			**NO SAMPLES** Interpreted as RESIDUAL PHYLLITE.
1 : 14	None			
1 : 37	None			
0 : 24	None			
1 : 24	None		95.0	
1 : 35	None			
1 : 42	None			
1 : 43	None			
1 : 43	None			
1 : 47	None		100.0	
1 : 30	None			
1 : 33	None		102.0	

Note; water struck at 79m.

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter	6.5in	x	34 J 0224645
Machine:	Thor	Date drilled	21/07/2010	y	6511291
Drilling operator:	Daniel	Recorded by:	Frank	z	74

CLIENT:	ESKOM	BKS Palace Consortium	**WTG 44**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 11	None	Good	
0 : 49	None	Good	
0 : 13	None	Good	
0 : 13	None	Good	
0 : 15	None	Good	5.0
0 : 06	None	Good	
0 : 19	None	Good	
0 : 11	None	Good	
0 : 11	None	Good	
0 : 10	None	Good	10.0
0 : 11	None	Good	
0 : 20	None	Good	
0 : 19	None	Good	
0 : 10	None	Good	
0 : 09	None	Good	15.0
0 : 15	None	Good	
0 : 06	None	Good	
0 : 12	None	Good	
0 : 14	None	Good	
0 : 12	None	Good	20.0
0 : 14	None	Good	
0 : 16	None	Good	
0 : 14	None	Good	
0 : 12	None	Good	
0 : 16	None	Good	25.0
0 : 11	None	Good	
0 : 09	None	Good	
0 : 11	None	Good	
0 : 08	None	Good	
0 : 15	None	Good	30.0
0 : 31	None	Good	
0 : 12	None	Good	
0 : 11	None	Good	
0 : 15	None	Good	
0 : 14	None	Good	35.0
0 : 21	None	Good	
0 : 19	None	Good	
0 : 09	None	Good	
0 : 16	None	Good	
0 : 09	None	Good	40.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
White to orange SAND. AEOLIAN.
Interpreted as cemented from rotary core logs.

CLAYEY SAND
Light orange clayey SAND. MARINE.

SAND
White SAND. MARINE.

SAND
White yellowish orange silty SAND. MARINE.

SAND
White SAND. MARINE.

SAND
Yellow and white SAND with minor pink subrounded quartz gravel. MARINE.

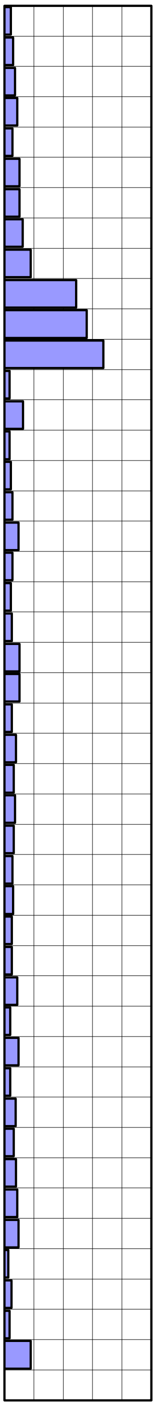
SAND
White SAND with grey fine subrounded quartz gravel. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225009
Machine:	Thor	Date drilled:	2010/02/08	y	6511151
Drilling operator:	Daniel	Recorded by:	Frank	z	69

CLIENT:	**ESKOM**	**BKS Palace Consortium**	**WTG 45**
SITE:	**KOEKENAAP WESTERN CAPE**		
INVESTIGATION:	**SERE WIND ENERGY FACILITY**		

JOB. NO. J01386

SHEET 1 OF 2



PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 11	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 15	None	Good		
0 : 18	None	Good		**SAND** Yellowish orange brown SAND. AEOLIAN.
0 : 22	None	Good		
0 : 14	None	Good	5.0	**SAND** Reddish brown SAND. AEOLIAN.
0 : 26	None	Good		
0 : 26	None	Good		**CLAYEY SAND** Reddish brown to yellow brown slightly clayey SAND. MARINE. Note, wet samples.
0 : 31	None	Good		
0 : 45	None	Good		
2 : 02	None	Good	10.0	
2 : 20	None	Good		**CLAYEY SAND** Brown slightly clayey SAND. MARINE. Note, wet samples.
2 : 48	None	Good		
0 : 09	None	Good		
0 : 32	None	Good		**SANDY SILT** Light brown slightly sandy SILT with traces of hard subrounded grey slightly weathered quartz gravel. MARINE. Note, wet samples.
0 : 09	None	Good	15.0	
0 : 11	None	Good		
0 : 14	None	Good		
0 : 24	None	Good		**SANDY SILT** Light brown to yellow brown sandy SILT with traces of hard subrounded quartz gravel. MARINE. (Sand is possibly contaminated).
0 : 14	None	Good		
0 : 11	None	Good	20.0	
0 : 13	None	Good		
0 : 26	None	Good		
0 : 26	None	Good		**FINE SAND** White to light brown fine grained SAND. MARINE.
0 : 13	None	Good		
0 : 20	None	Good	25.0	
0 : 16	None	Good		
0 : 18	None	Good		
0 : 16	None	Good		
0 : 14	None	Good		
0 : 15	None	Good	30.0	
0 : 13	None	Good		
0 : 13	None	Good		
0 : 22	None	Good		
0 : 10	None	Good		
0 : 24	None	Good	35.0	
0 : 10	None	Good		
0 : 19	None	Good		**FINE SAND** White to light brown fine grained SAND with traces of subrounded slightly weathered gravel. MARINE.
0 : 16	None	Good		
0 : 20	None	Good		
0 : 22	None	Good	40.0	
0 : 24	None	Good		
0 : 07	None	Good		
0 : 12	None	Good		**SILTY SAND** Light brown and light grey silty SAND with traces of grey slightly weathered quartz gravel (2-8mm). MARINE.
0 : 09	None	Good		
0 : 45	None	Good	45.0	

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter	6.5in	x	34 J 0225499
Machine:	Thor	Date drilled	21/07/2010	y	6510926
Drilling operator:	Daniel	Recorded by:	Frank	z	71

CLIENT:	**ESKOM**
SITE:	**KOEKENAAP WESTERN CAPE**
INVESTIGATION:	**SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 45

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 30	None	Good	
0 : 22	None	Good	
0 : 19	None	Good	
0 : 30	None	Good	
0 : 34	None	Good	50.0
0 : 29	None	Good	
0 : 17	None	Good	
0 : 29	None	Good	
0 : 39	None	Good	
0 : 28	None	Good	55.0
0 : 09	None	Good	
0 : 16	None	Good	
0 : 11	None	Good	
0 : 10	None	Good	
0 : 13	None	Good	60.0
0 : 20	None	Good	
0 : 22	None	Good	
0 : 17	None	Good	
0 : 14	None	Good	
0 : 18	None	Good	65.0
0 : 29	None	Good	
0 : 25	None	Good	
0 : 34	None	Good	
0 : 21	None	Good	
0 : 29	None	Good	70.0
0 : 16	None	Good	
0 : 26	None	Good	
0 : 38	None	Good	
0 : 28	None	Good	
0 : 17	None	Good	75.0
0 : 22	None	Good	
0 : 25	None	Good	
0 : 36	None	Good	
1 : 02	None	Good	
0 : 46	None	Good	80.0
0 : 43	None	Good	
0 : 43	None	Good	
0 : 29	None	Good	
0 : 54	None	Good	84.0
	None		
	None		
	None		
	None		
	None		
	None		

DESCRIPTION

SILTY SAND
Light brown and light grey silty SAND with traces of grey slightly weathered quartz gravel (2-8mm). MARINE.

SILTY SAND
Light brown and light grey silty SAND with minor grey slightly weathered quartz gravel (2-8mm). MARINE.

SILTY SAND
Light brown silty SAND with minor grey slightly weathered quartz gravel (2-8mm). MARINE.

SAND
Light brown SAND with rounded hard moderately weathered quartz chips. MARINE. Samples taken.

Note; borehole terminated at 84m due to borehole side walls collapse/unstable side walls and rods getting stuck.

Profiled by:	J Ehlers	Compressor	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter	6.5in	x	34 J 0225499
Machine:	Thor	Date drilled	21/07/2010	y	6510926
Drilling operator:	Daniel	Recorded by:	Frank	z	71

CLIENT:	ESKOM	**BKS Palace Consortium**	**WTG 46**
SITE:	KOEKENAAP WESTERN CAPE		JOB. NO. J01386
INVESTIGATION:	SERE WIND ENERGY FACILITY		SHEET 1 OF 1

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0 : 04	None	Good	
0 : 35	None	Good	
0 : 56	None	Good	
0 : 29	None	Good	
0 : 09	None	Good	5.0
0 : 23	None	Good	
0 : 48	None	Good	
0 : 49	None	Good	
0 : 33	None	Good	
0 : 35	None	Good	10.0
1 : 36	None	Good	
0 : 25	None	Good	
0 : 24	None	Good	
0 : 23	None	Good	
0 : 27	None	Good	15.0
1 : 17	None	Good	
0 : 49	None	Good	
0 : 23	None	Good	
1 : 08	None	Good	
1 : 33	None	Good	20.0
1 : 03	None	Good	
1 : 43	None	Good	
0 : 34	None	Good	
1 : 16	None	Good	
0 : 37	None	Good	25.0
0 : 38	None	Good	
0 : 32	None	Good	
0 : 39	None	Good	
0 : 22	None	Good	
0 : 23	None	Good	30.0
0 : 53	None	Good	
0 : 56	None	Good	
1 : 12	None	Good	
1 : 04	None	Good	
1 : 54	None	Good	35.0
1 : 51	None	Good	
1 : 46	None	Good	
0 : 51	None	Good	
1 : 56	None	Good	
2 : 05	None	Good	40.0

DESCRIPTION

SAND
Pale red SAND AEOLIAN.

CLAYEY SAND
Orange yellow clayey SAND. MARINE.

CLAYEY SAND
Red to orange clayey SAND. MARINE.

SAND
Orange to grey SAND with minor gravel. MARINE.

SANDY SILT
Brown red sandy SILT. MARINE.

SILT
Light brown to white SILT. MARINE.

SANDY SILT
Grey and white calcareous sandy SILT. MARINE.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0225893
Machine:	Thor	Date drilled:	2010/02/08	y	6510742
Drilling operator:	Daniel	Recorded by:	Frank	z	75

CLIENT:	ESKOM	**BKS Palace Consortium**
SITE:	KOEKENAAP WESTERN CAPE	
INVESTIGATION:	SERE WIND ENERGY FACILITY	

WTG 47

JOB. NO. J01386

SHEET 1 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
0 : 06	None	Good		**SAND** Pale red SAND. AEOLIAN.
0 : 07	None	Good		
1 : 19	None	Good		
0 : 59	None	Good		
0 : 48	None	Good	5.0	
0 : 47	None	Good		
0 : 43	None	Good		**SAND** Orange brown SAND. AEOLIAN.
0 : 40	None	Good		
0 : 39	None	Good		
0 : 43	None	Good	10.0	
0 : 28	None	Good		
0 : 22	None	Good		
0 : 28	None	Good		
0 : 33	None	Good		
0 : 26	None	Good	15.0	
0 : 22	None	Good		
0 : 17	None	Good		**SAND** Yellowish brown SAND. AEOLIAN.
0 : 23	None	Good		
0 : 15	None	Good		
0 : 09	None	Good	20.0	
0 : 11	None	Good		
0 : 26	None	None		**NO SAMPLES** Interpreted as SAND. AEOLIAN.
0 : 14	None	None		
0 : 09	None	None		
0 : 22	None	Good	25.0	**SAND** Brown SAND. AEOLIAN.
1 : 09	None	Good		
1 : 10	None	Good		**SANDY SILT** Light brown and grey sandy SILT. MARINE. (Sand can be contaminated).
1 : 10	None	Good		
0 : 58	None	Good		
0 : 09	None	Good	30.0	
1 : 03	None	Good		
1 : 02	None	Good		
1 : 22	None	Good		
0 : 53	None	Good		
0 : 39	None	Good	35.0	
0 : 49	None	Good		
0 : 54	None	Good		
0 : 49	None	Good		
0 : 54	None	Good		**CLAYEY SILT** Dark grey slightly clayey SILT. MARINE.
1 : 06	None	Good	40.0	
1 : 21	None	Good		
0 : 58	None	Good		
0 : 59	None	Good		
1 : 02	None	Good		
1 : 05	None	Good	45.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0226298
Machine:	Thor	Date drilled:	22/07/2010	y	6510685
Drilling operator:	Daniel	Recorded by:	Frank	z	79

CLIENT:	ESKOM	**BKS Palace Consortium**	**WTG 47**
SITE:	KOEKENAAP WESTERN CAPE		
INVESTIGATION:	SERE WIND ENERGY FACILITY		

JOB. NO. J01386

SHEET 2 OF 2

PENETRATION TIME (Min : Sec)	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)	DESCRIPTION
2 : 42	None	None		**NO SAMPLE RETURN** Interpreted as CLAY or SILT. MARINE.
1 : 16	None	None		
1 : 36	None	None		
3 : 56	None	None		
1 : 44	None	None	50.0	
2 : 41	None	None		
3 : 07	None	None		
3 : 20	None	None		
3 : 48	None	None		
2 : 54	None	None	55.0	
3 : 39	None	None		
4 : 49	None	None	57.0	

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0226298
Machine:	Thor	Date drilled:	22/07/2010	y	6510685
Drilling operator:	Daniel	Recorded by:	Frank	z	79

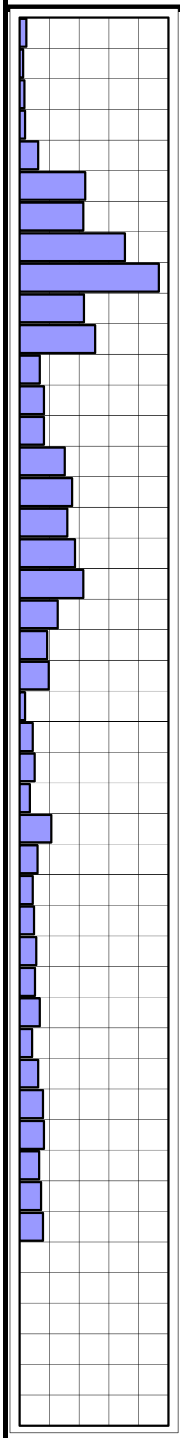
CLIENT:	**ESKOM**
SITE:	**KOEKENAAP WESTERN CAPE**
INVESTIGATION:	**SERE WIND ENERGY FACILITY**

BKS Palace Consortium

WTG 49

JOB. NO. J01386

SHEET 1 OF 1



PENETRATION TIME Min	Sec	AIR LOSS	SAMPLE RECOVERY	DEPTH (m)
0	11	None	Good	
0	06	None	Good	
0	08	None	Good	
0	09	None	Good	
0	31	None	Good	5.0
1	50	None	Good	
1	47	None	Good	
2	57	None	Good	
3	54	None	Good	
1	48	None	Good	10.0
2	07	None	Good	
0	34	None	Good	
0	41	None	Good	
0	41	None	Good	
1	16	None	Good	15.0
1	28	None	Good	
1	20	None	Good	
1	33	None	Good	
1	47	None	Good	
1	04	None	Good	20.0
0	46	None	Good	
0	49	None	Good	
0	09	None	Good	
0	22	None	Good	
0	25	None	Good	25.0
0	17	None	Good	
0	53	None	Good	
0	30	None	Good	
0	22	None	Good	
0	24	None	Good	30.0
0	28	None	Good	
0	26	None	Good	
0	34	None	Good	
0	21	None	Good	
0	31	None	Good	35.0
0	39	None	Good	
0	41	None	Good	
0	33	None	Good	
0	36	None	Good	
0	39	None	Good	40.0

DESCRIPTION

SAND
Pale red SAND. AEOLIAN.

SAND
Orange brown SAND. AEOLIAN.

FINE SAND
Light brown fine SAND. Interpreted as RESIDUAL QUARTZITE.

QUARTZITE
Light brown fine SAND with minor angular light brown hard quartz gravel (3-6mm). Interpreted as slightly weathered QUARTZITE BEDROCK.

FINE SAND
Reddish brown fine sand with light brown hard quartz gravel (3-6mm). Interpreted as weathered QUARTZITE BEDROCK with contamination.

FINE SAND
Light brown fine SAND with minor angular light brown hard quartz gravel (3-6mm). Interpreted as slightly weathered QUARTZITE BEDROCK.

SAND
White to light brown slightly weathered quartz (2-8mm chips) with minor fine SAND. Interpreted as QUARTZITE BEDROCK.

Profiled by:	J Ehlers	Compressor:	21 bar	Coordinates	
Drilling Contractor:	121 Drilling	Diameter:	6.5in	x	34 J 0227068
Machine:	Thor	Date drilled:	30/07/2010	y	6510586
Drilling operator:	Daniel	Recorded by:	Frank	z	71

APPENDIX F:

DPSH RESULTS

APPENDIX F:

DPSH RESULTS

a) Substation
b) Wind Turbine Positions

APPENDIX F:

DPSH RESULTS

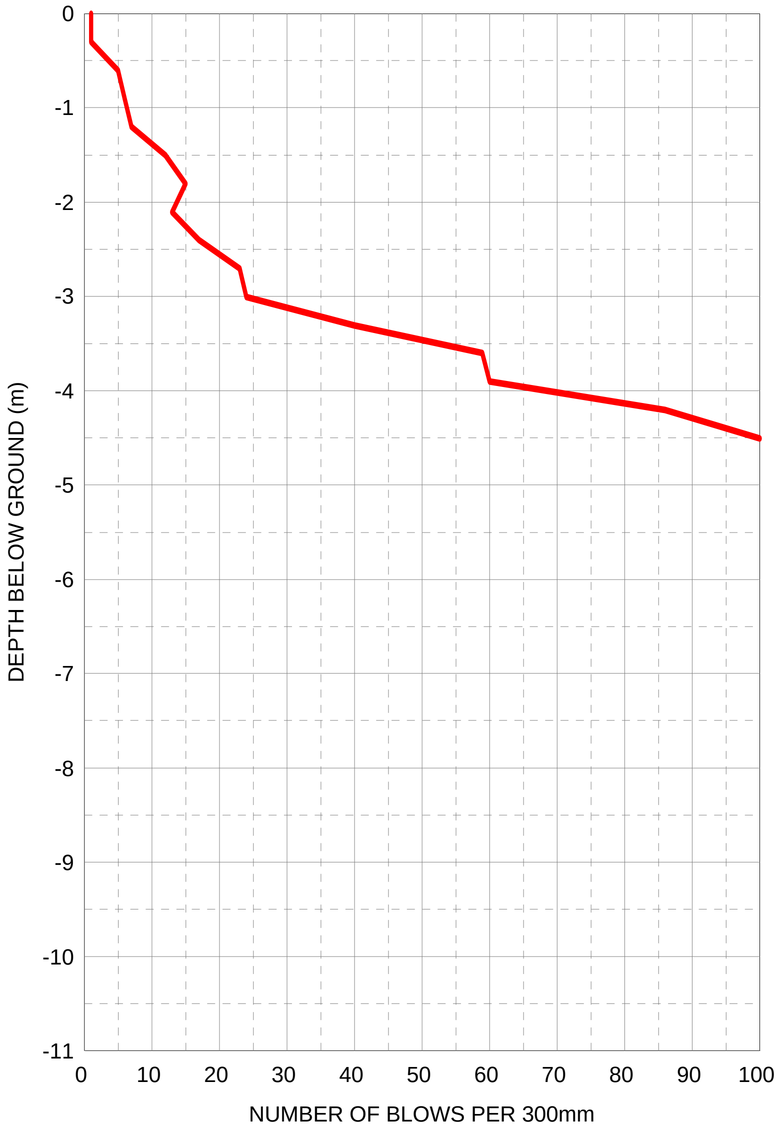
a) Substation

GEOPRACTICA
SOILS & MATERIALS TESTING
P.O.BOX 227, MARAISBURG, 1700
TEL: (011) 674 1325
FAX: (011) 674 4513
e mail: lab@geopractica.co.za

DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - A
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	5
0.9	6
1.2	7
1.5	12
1.8	15
2.1	13
2.4	17
2.7	23
3.0	24
3.3	40
3.6	59
3.9	60
4.2	86
4.5	100
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

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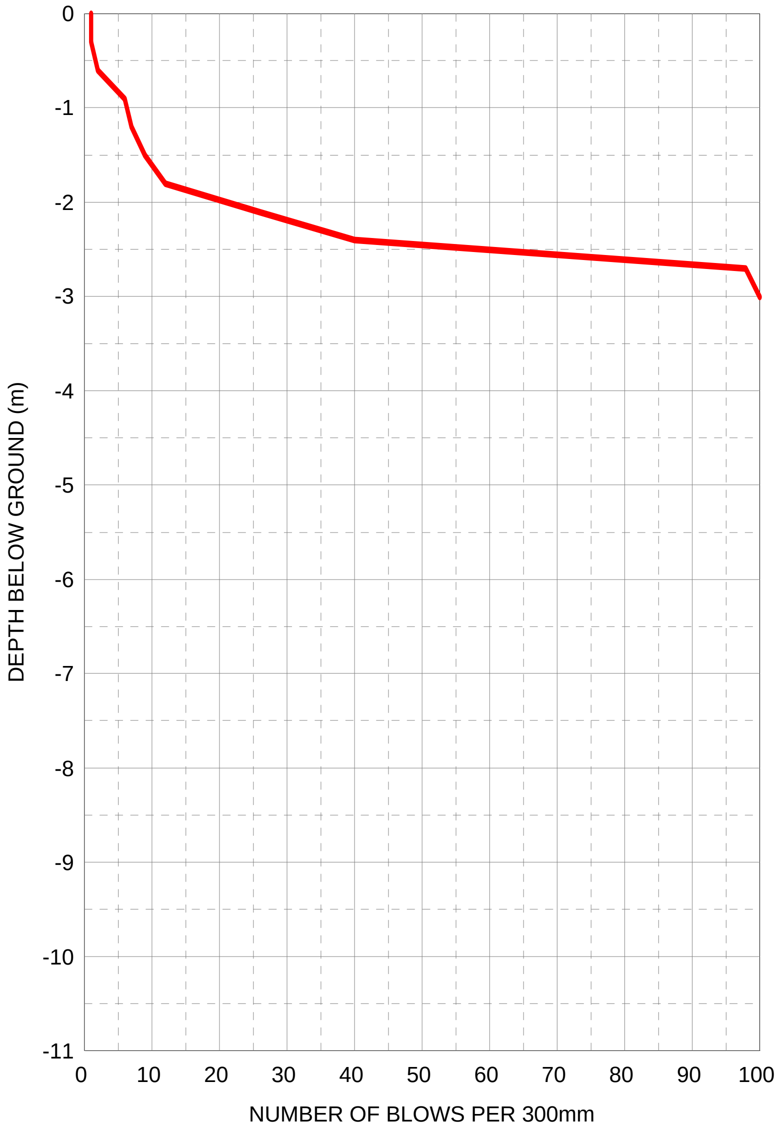
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - B
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	2
0.9	6
1.2	7
1.5	9
1.8	12
2.1	26
2.4	40
2.7	98
3.0	100
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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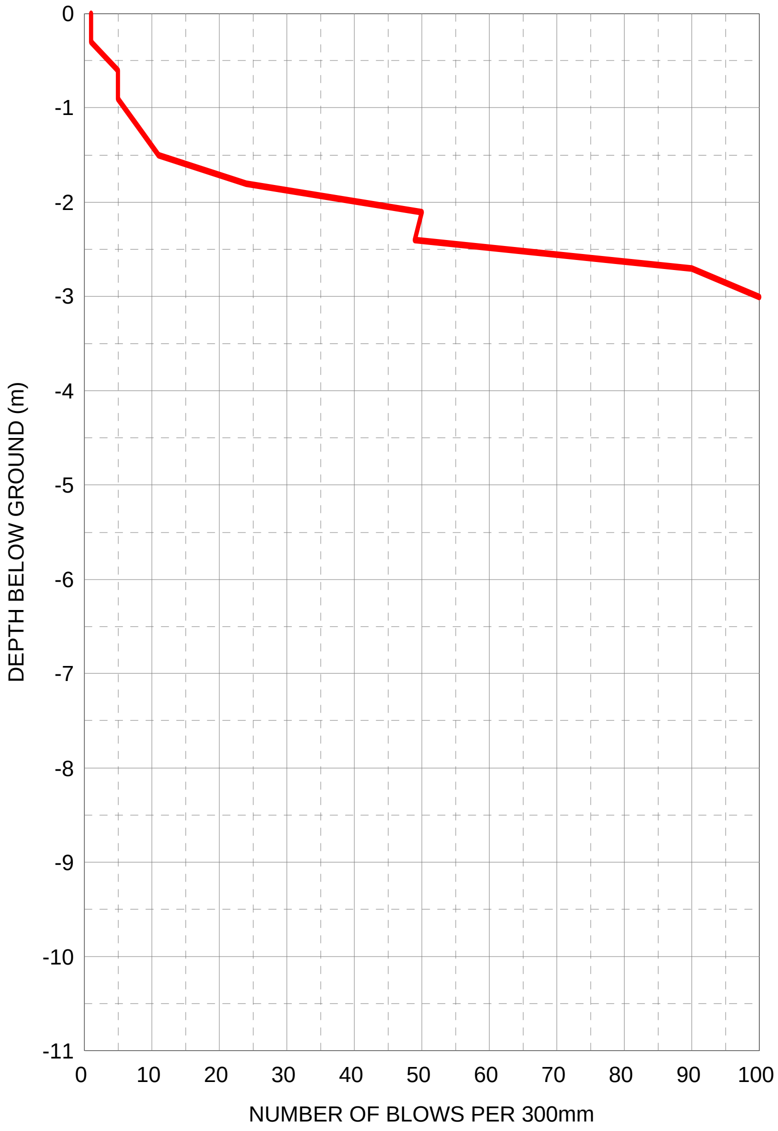
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - C
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	5
0.9	5
1.2	8
1.5	11
1.8	24
2.1	50
2.4	49
2.7	90
3.0	100
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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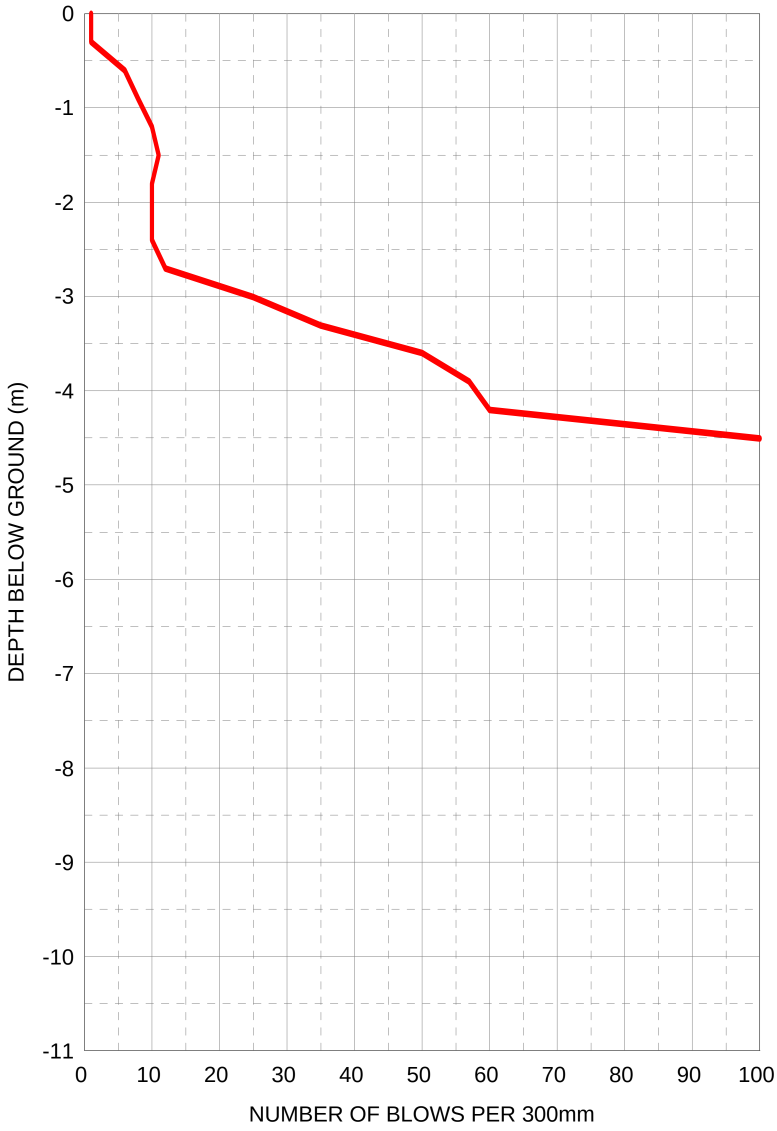
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - D
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	6
0.9	8
1.2	10
1.5	11
1.8	10
2.1	10
2.4	10
2.7	12
3.0	25
3.3	35
3.6	50
3.9	57
4.2	60
4.5	100
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

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Revision No 2 (19/04/2002)

APPENDIX F:

DPSH RESULTS

b) Wind Turbine Positions

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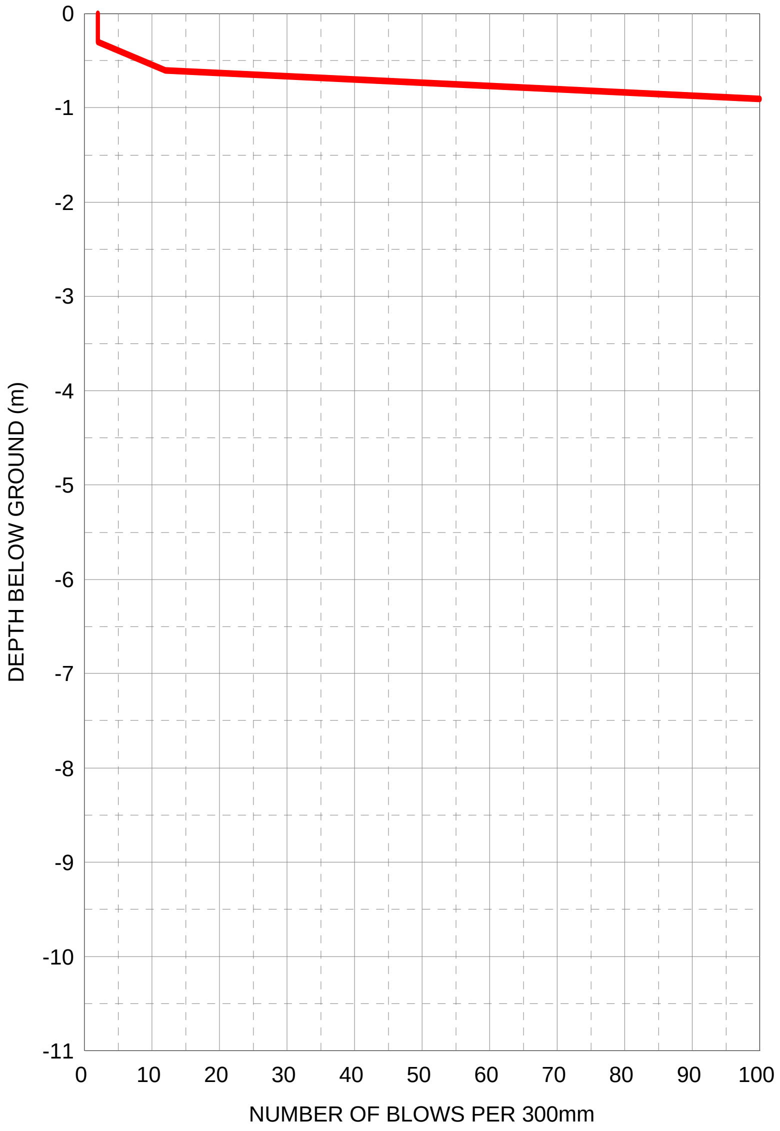
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 1 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	12
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm | | Blows

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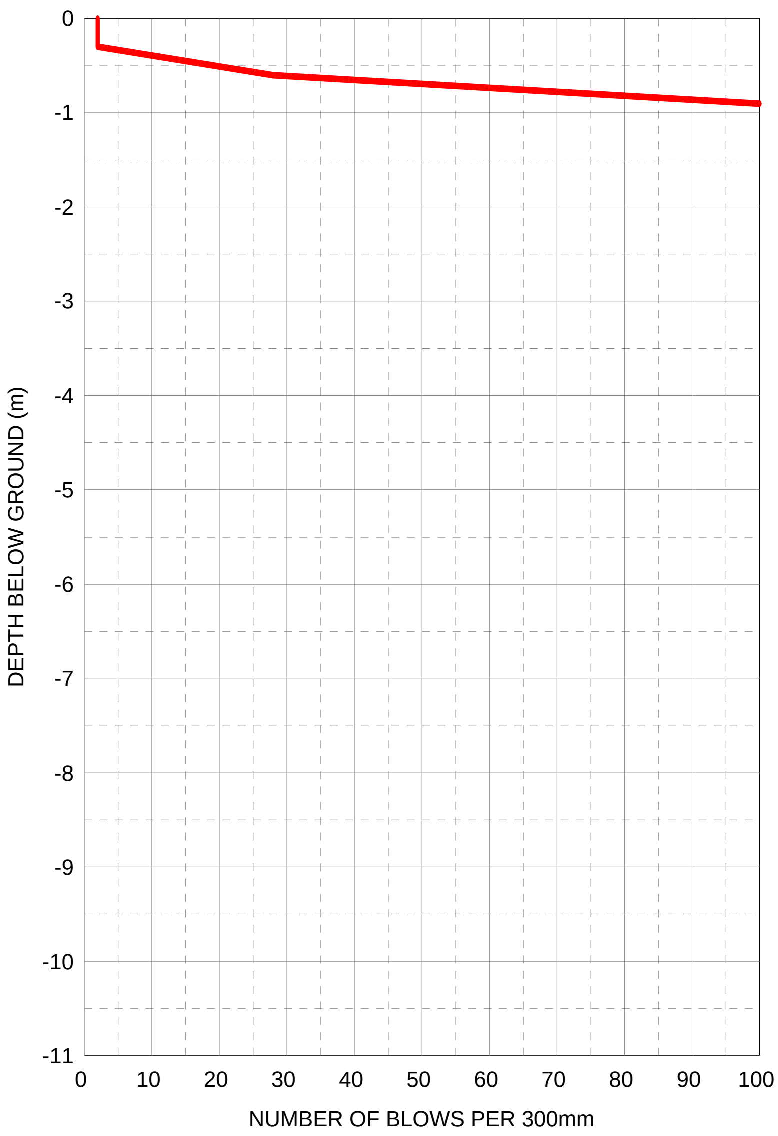
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 1 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	28
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 2
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	5
0.9	10
1.2	22
1.5	22
1.8	25
2.1	38
2.4	29
2.7	24
3.0	25
3.3	25
3.6	24
3.9	24
4.2	24
4.5	30
4.8	32
5.1	32
5.4	33
5.7	30
6.0	31
6.3	35
6.6	37
6.9	40
7.2	49
7.5	76
7.8	92
8.1	100
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	

RE-DRIVE LAST 300mm	0	Blows

Programe Data
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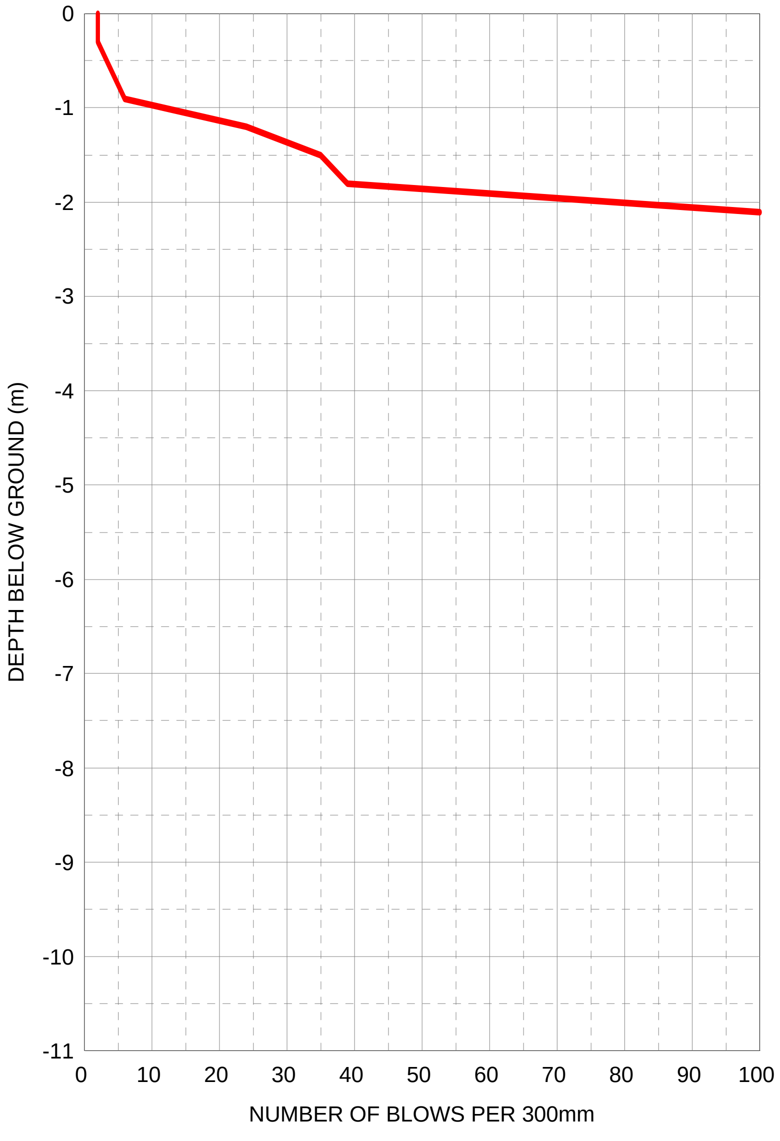
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 4
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	6
1.2	24
1.5	35
1.8	39
2.1	100
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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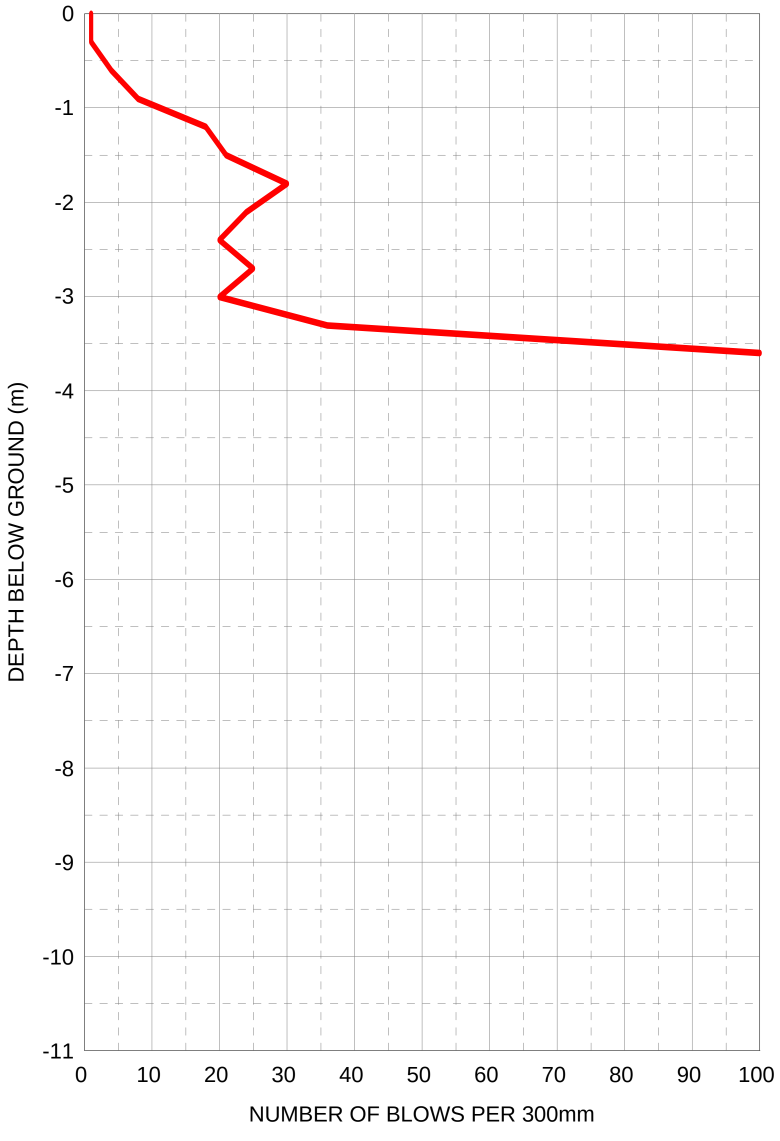
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 6
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	8
1.2	18
1.5	21
1.8	30
2.1	24
2.4	20
2.7	25
3.0	20
3.3	36
3.6	100
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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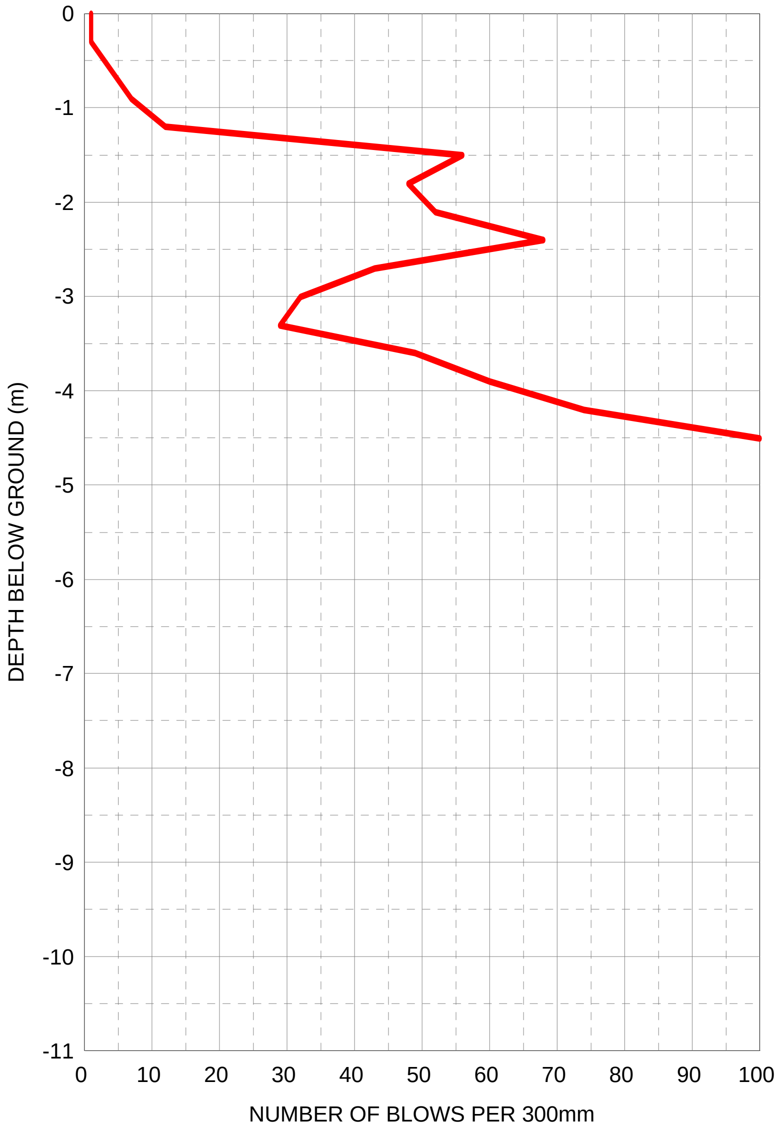
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 8
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	7
1.2	12
1.5	56
1.8	48
2.1	52
2.4	68
2.7	43
3.0	32
3.3	29
3.6	49
3.9	60
4.2	74
4.5	100
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

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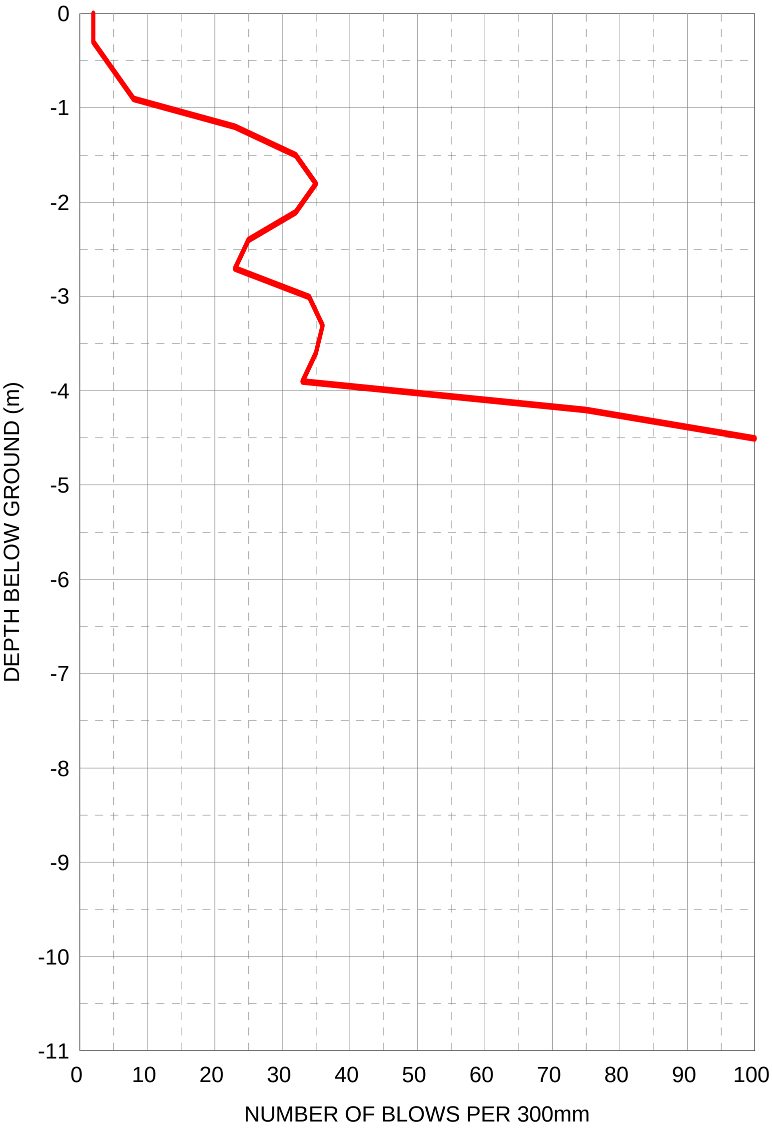
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 10
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	5
0.9	8
1.2	23
1.5	32
1.8	35
2.1	32
2.4	25
2.7	23
3.0	34
3.3	36
3.6	35
3.9	33
4.2	75
4.5	100
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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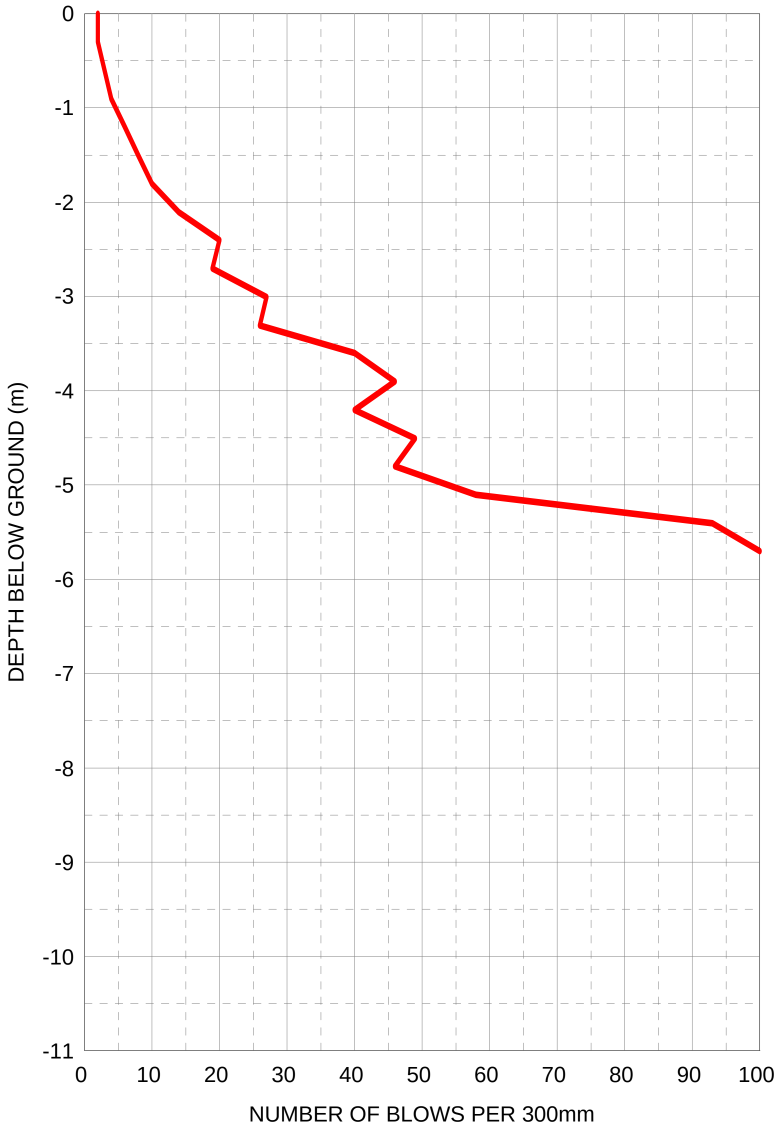
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 12
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	3
0.9	4
1.2	6
1.5	8
1.8	10
2.1	14
2.4	20
2.7	19
3.0	27
3.3	26
3.6	40
3.9	46
4.2	40
4.5	49
4.8	46
5.1	58
5.4	93
5.7	100
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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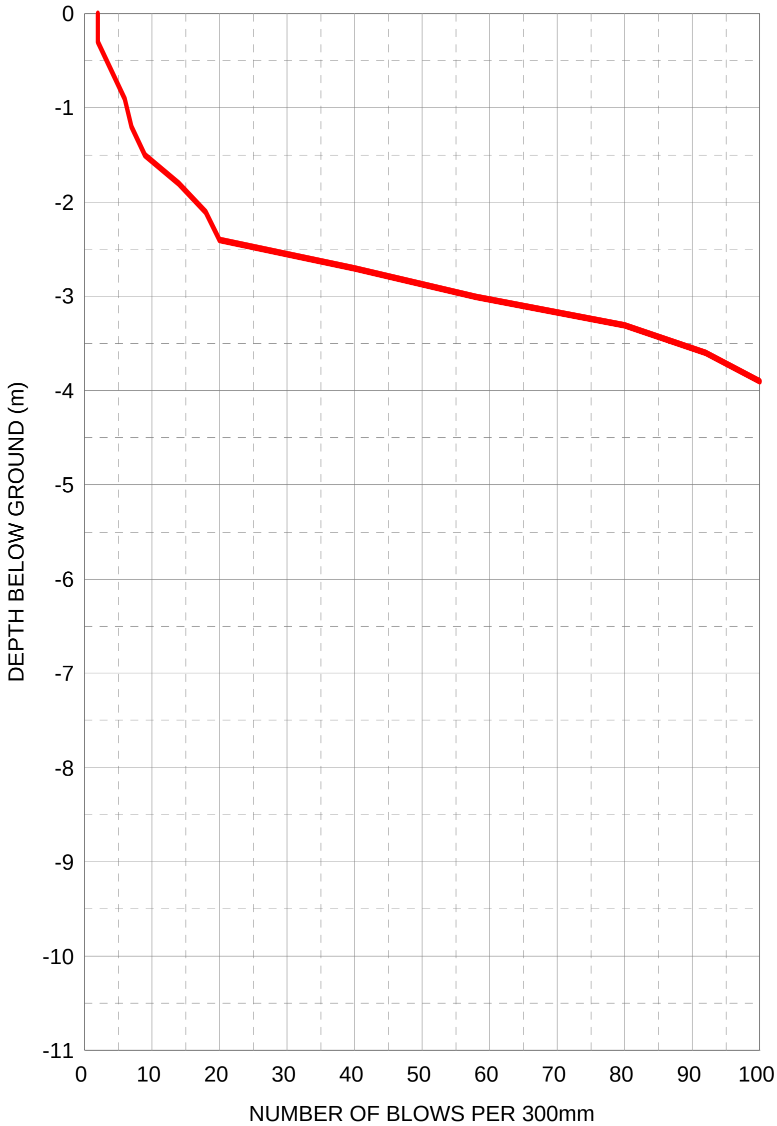
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 14
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	6
1.2	7
1.5	9
1.8	14
2.1	18
2.4	20
2.7	40
3.0	58
3.3	80
3.6	92
3.9	100
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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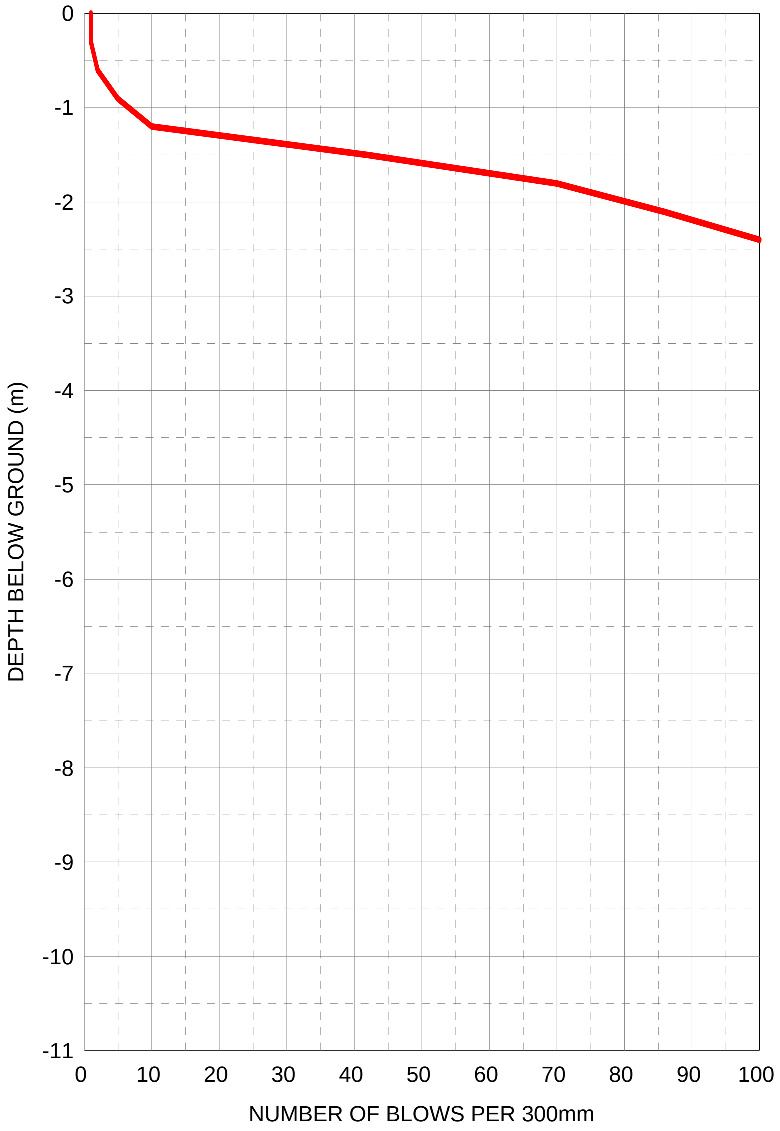
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 16
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	2
0.9	5
1.2	10
1.5	42
1.8	70
2.1	86
2.4	100
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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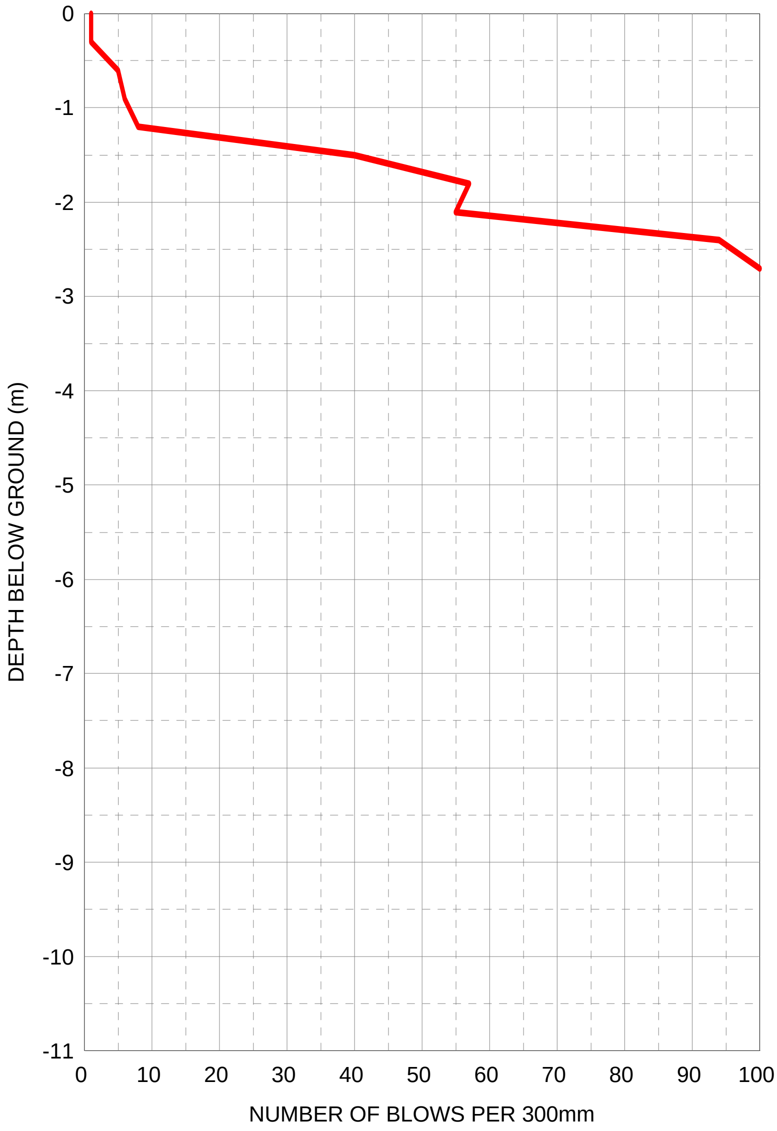
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 18
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	5
0.9	6
1.2	8
1.5	40
1.8	57
2.1	55
2.4	94
2.7	100
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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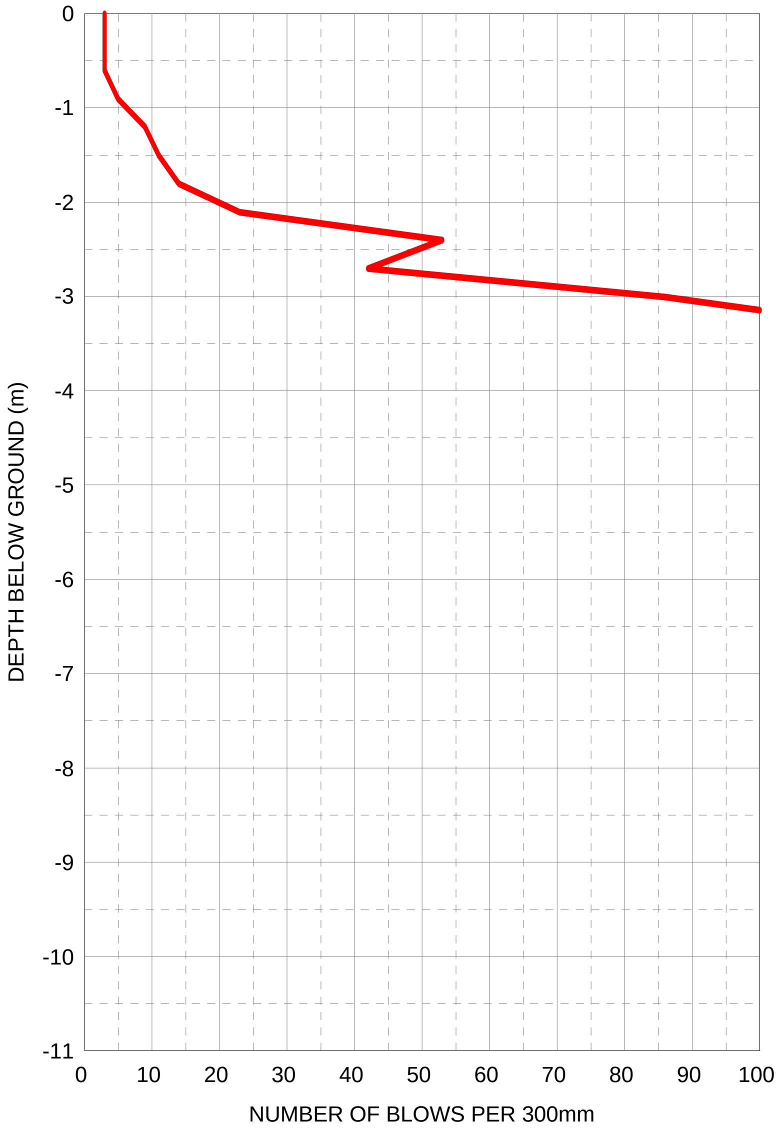
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 19
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	3
0.9	5
1.2	9
1.5	11
1.8	14
2.1	23
2.4	53
2.7	42
3.0	86
3.3	115
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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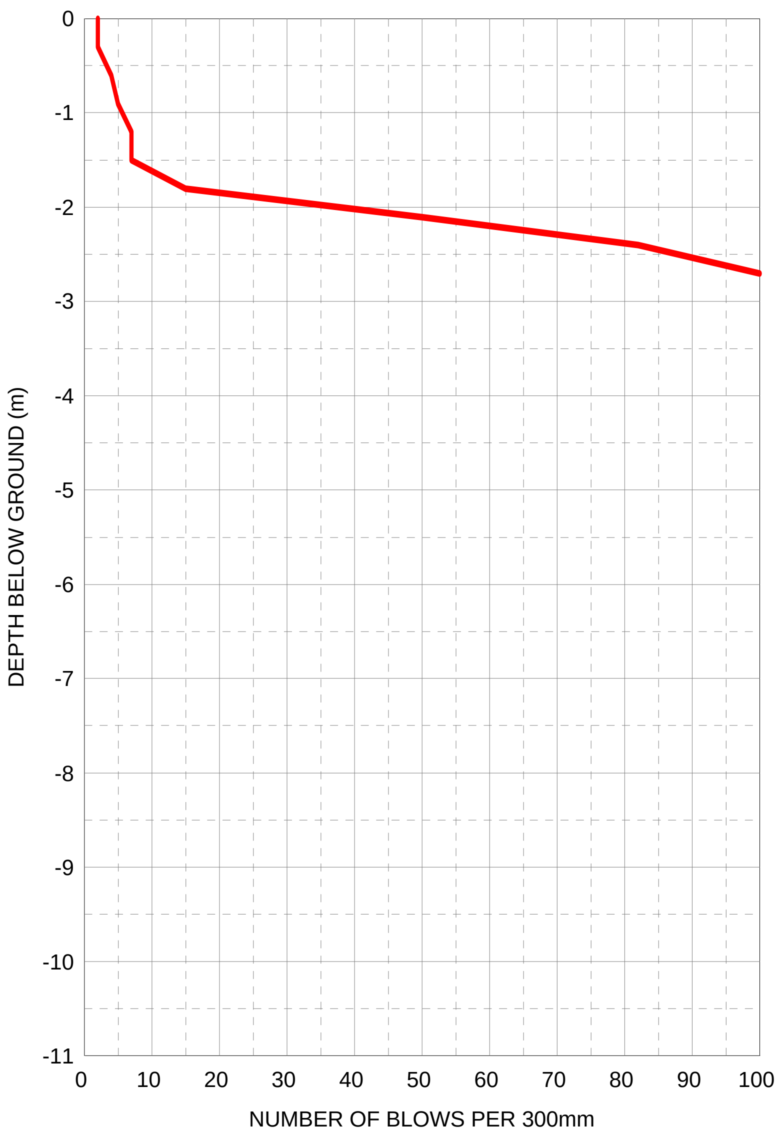
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 20
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	5
1.2	7
1.5	7
1.8	15
2.1	50
2.4	82
2.7	100
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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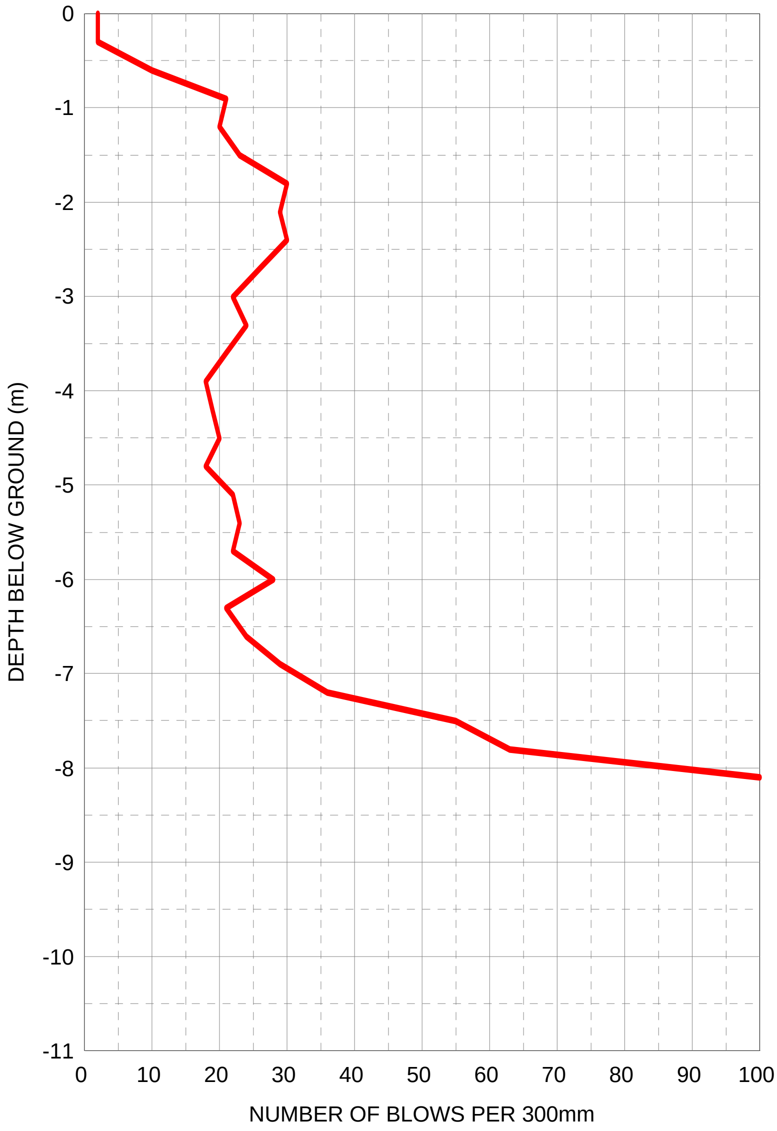
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 21
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	10
0.9	21
1.2	20
1.5	23
1.8	30
2.1	29
2.4	30
2.7	26
3.0	22
3.3	24
3.6	21
3.9	18
4.2	19
4.5	20
4.8	18
5.1	22
5.4	23
5.7	22
6.0	28
6.3	21
6.6	24
6.9	29
7.2	36
7.5	55
7.8	63
8.1	100
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	1	Blows

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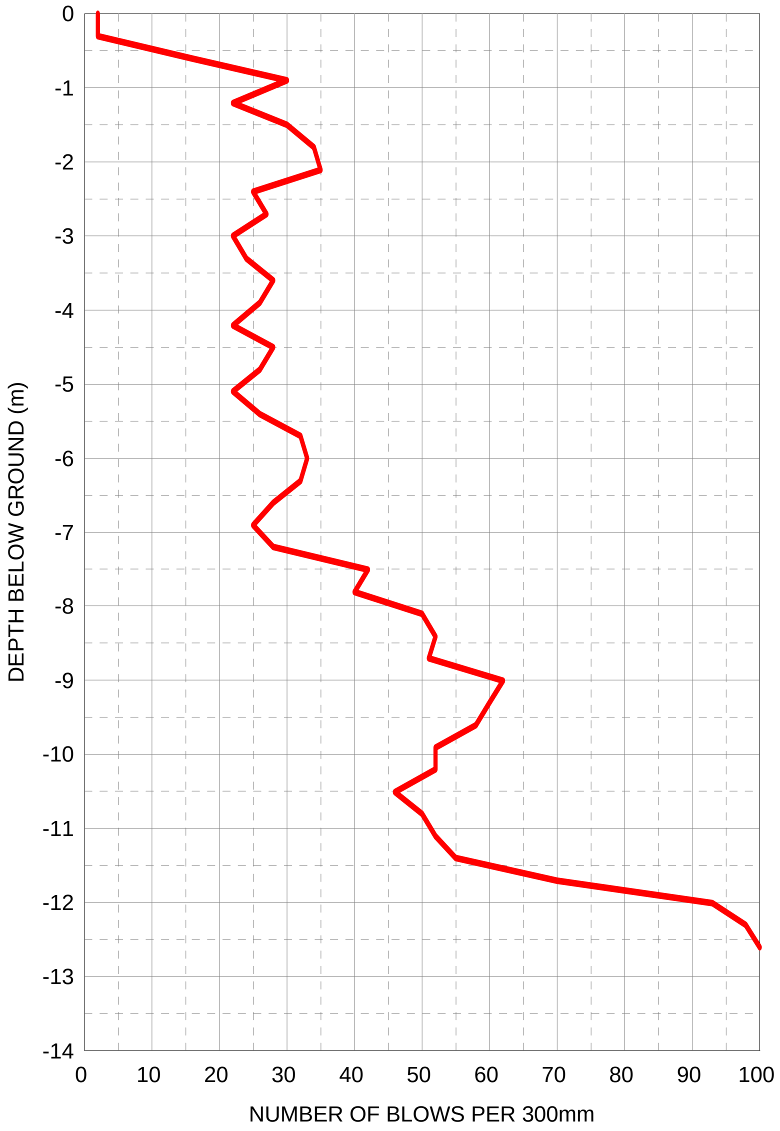
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL ENGINEERS		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 22
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	16
0.9	30
1.2	22
1.5	30
1.8	34
2.1	35
2.4	25
2.7	27
3.0	22
3.3	24
3.6	28
3.9	26
4.2	22
4.5	28
4.8	26
5.1	22
5.4	26
5.7	32
6.0	33
6.3	32
6.6	28
6.9	25
7.2	28
7.5	42
7.8	40
8.1	50
8.4	52
8.7	51
9.0	62
9.3	60
9.6	58
9.9	52
10.2	52
10.5	46
10.8	50
11.1	52
11.4	55
11.7	70
12.0	93
12.3	98
12.6	100
12.9	
13.2	
13.5	
13.8	
14.1	
14.4	
14.7	
15.0	



RE-DRIVE LAST 300mm	2	Blows

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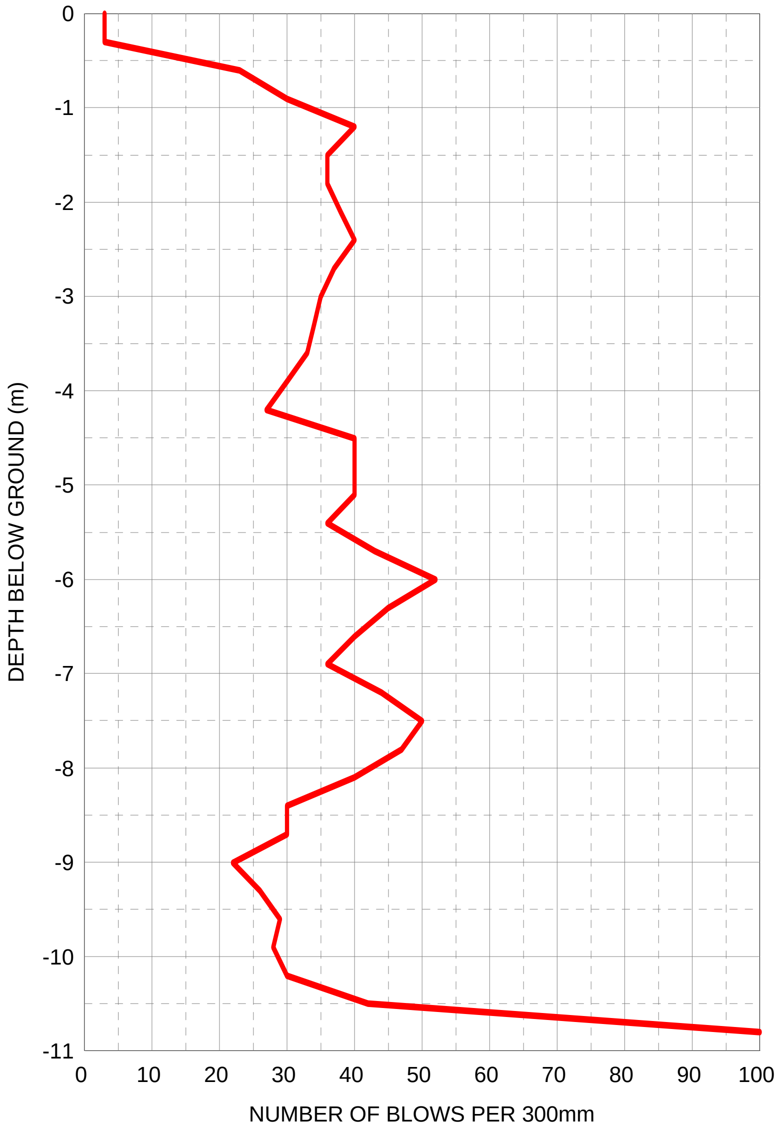
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 23
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	23
0.9	30
1.2	40
1.5	36
1.8	36
2.1	38
2.4	40
2.7	37
3.0	35
3.3	34
3.6	33
3.9	30
4.2	27
4.5	40
4.8	40
5.1	40
5.4	36
5.7	43
6.0	52
6.3	45
6.6	40
6.9	36
7.2	44
7.5	50
7.8	47
8.1	40
8.4	30
8.7	30
9.0	22
9.3	26
9.6	29
9.9	28
10.2	30
10.5	42
10.8	100
11.1	



RE-DRIVE LAST 300mm	0	Blows

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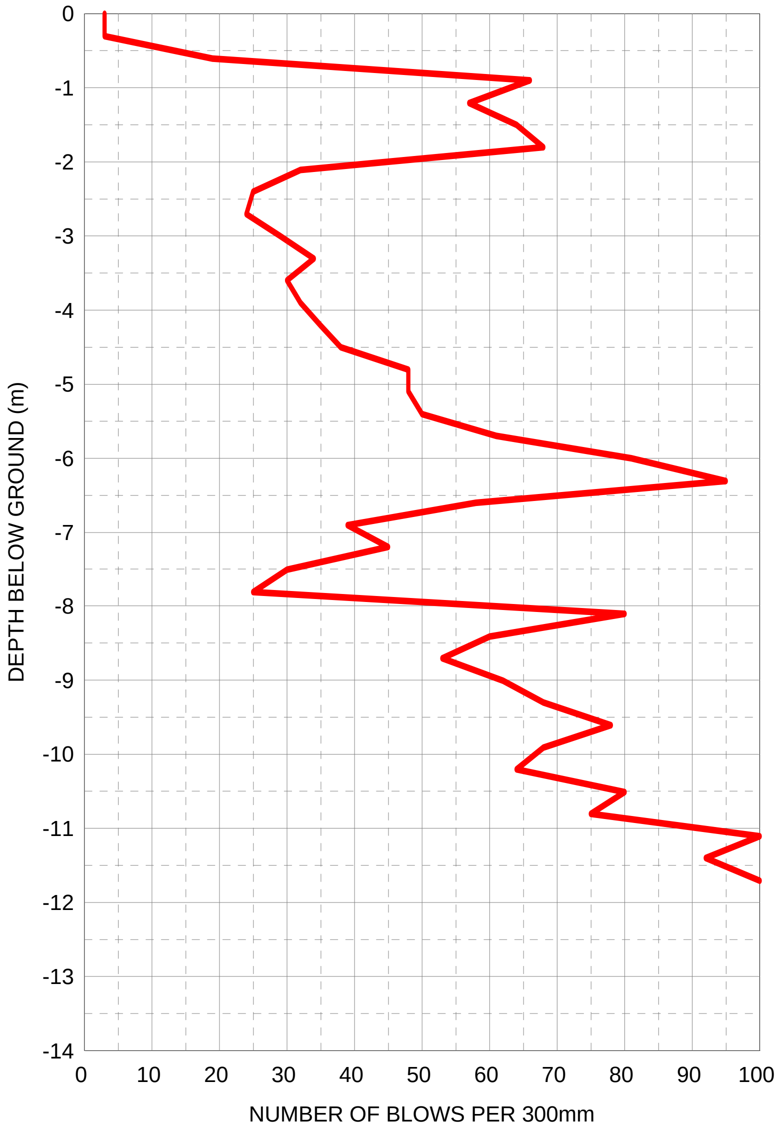
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL ENGINEERS		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 24
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	19
0.9	66
1.2	57
1.5	64
1.8	68
2.1	32
2.4	25
2.7	24
3.0	29
3.3	34
3.6	30
3.9	32
4.2	35
4.5	38
4.8	48
5.1	48
5.4	50
5.7	61
6.0	81
6.3	95
6.6	58
6.9	39
7.2	45
7.5	30
7.8	25
8.1	80
8.4	60
8.7	53
9.0	62
9.3	68
9.6	78
9.9	68
10.2	64
10.5	80
10.8	75
11.1	100
11.4	92
11.7	100
12.0	
12.3	
12.6	
12.9	
13.2	
13.5	
13.8	
14.1	
14.4	
14.7	
15.0	



RE-DRIVE LAST 300mm	0	Blows

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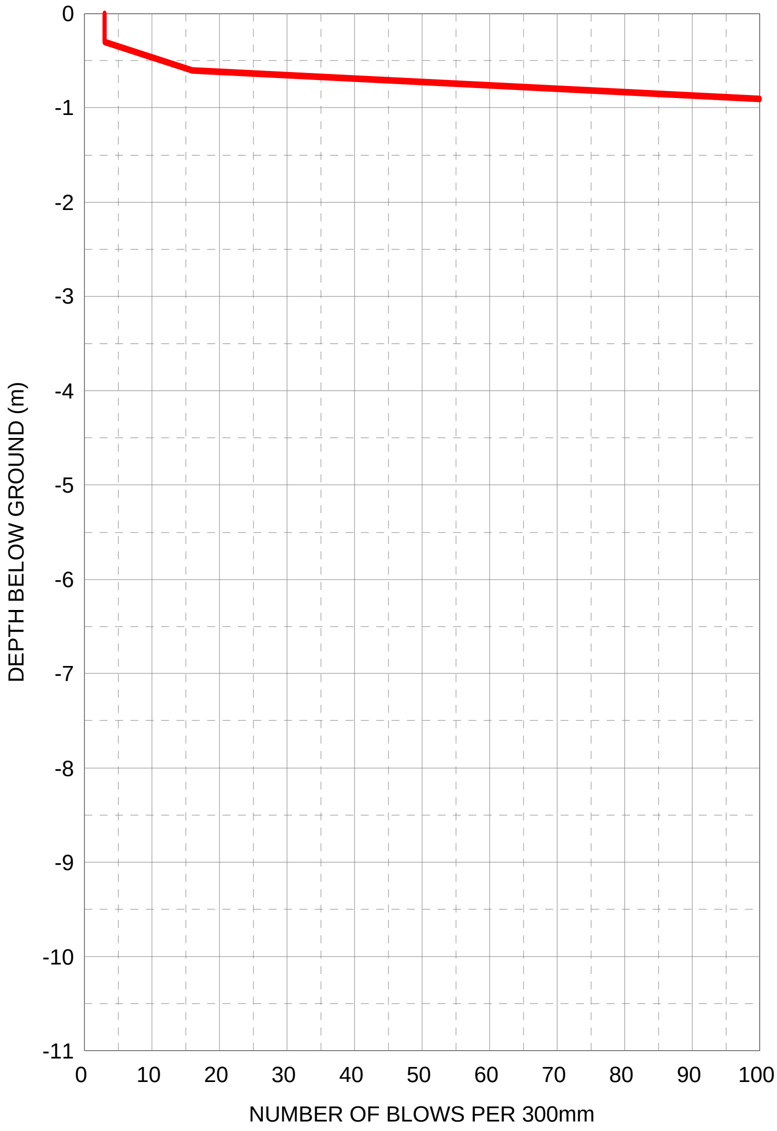
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 25
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	16
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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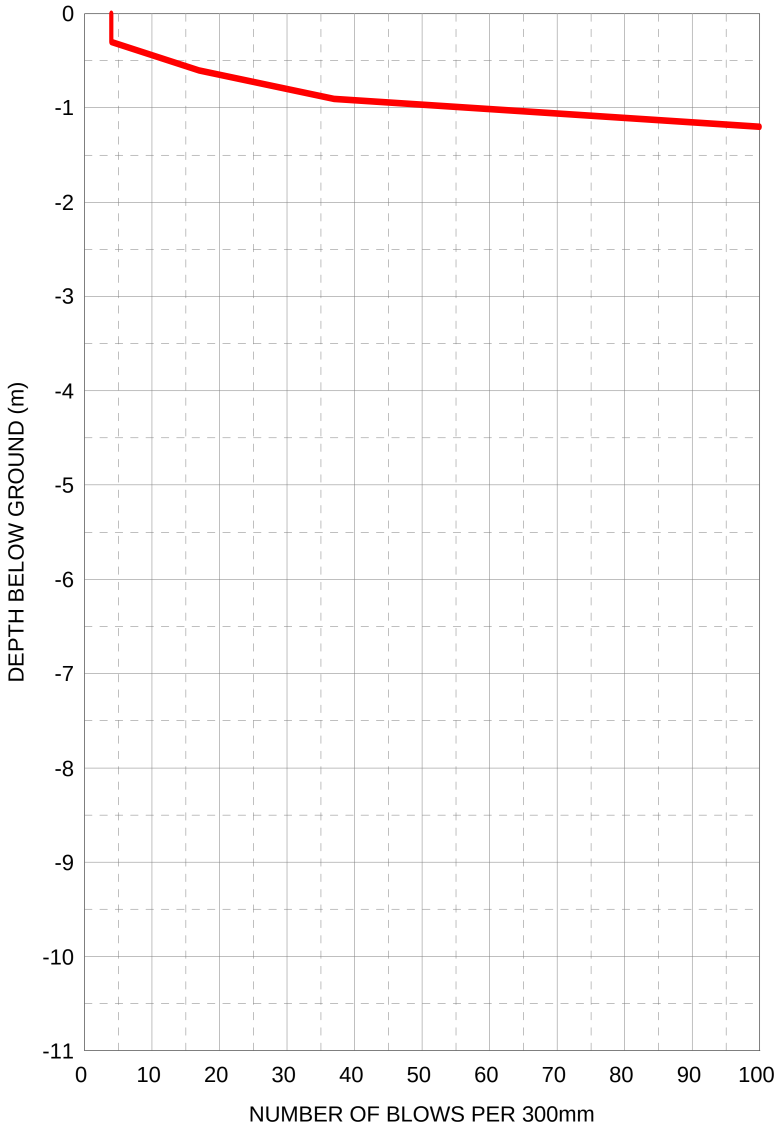
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 26
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	4
0.6	17
0.9	37
1.2	100
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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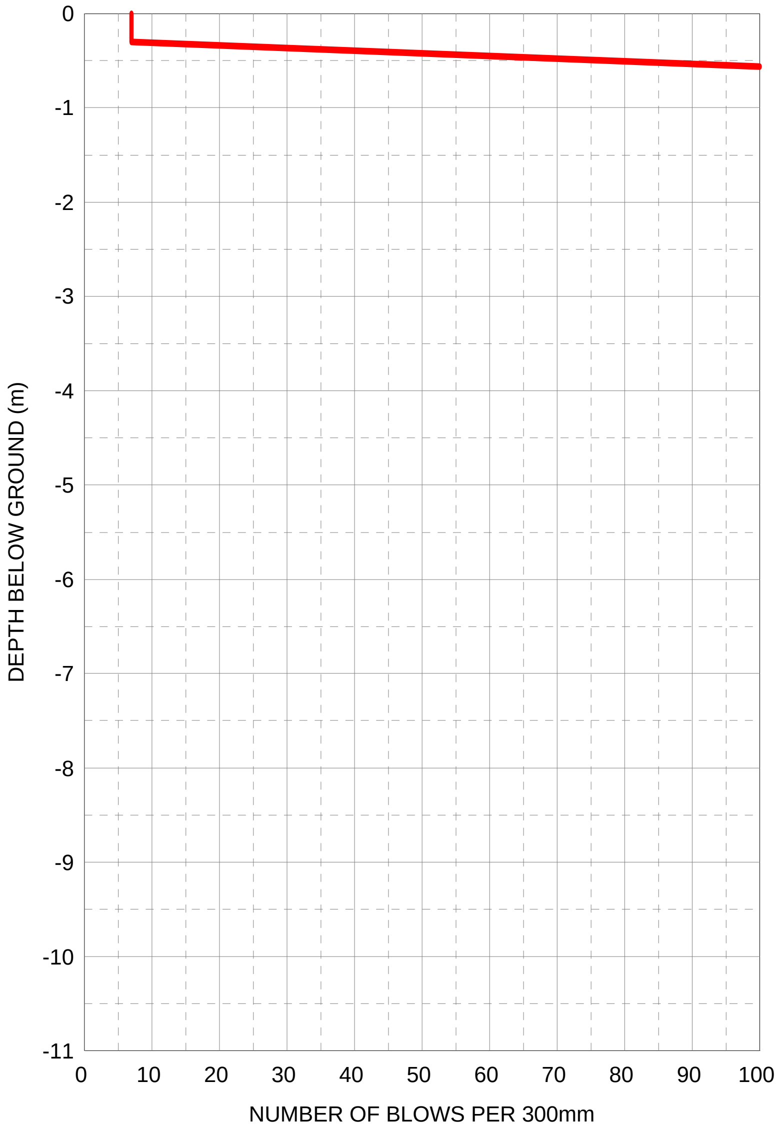
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 27 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	7
0.6	115
0.9	
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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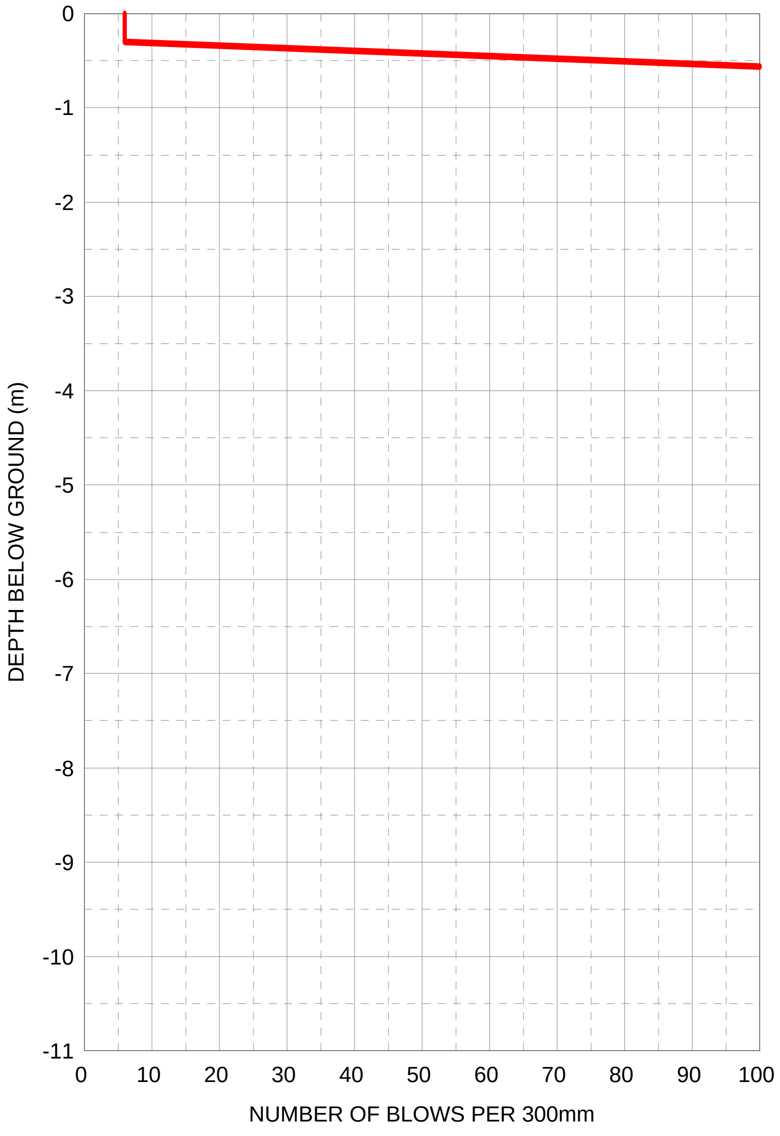
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 27 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	6
0.6	116
0.9	
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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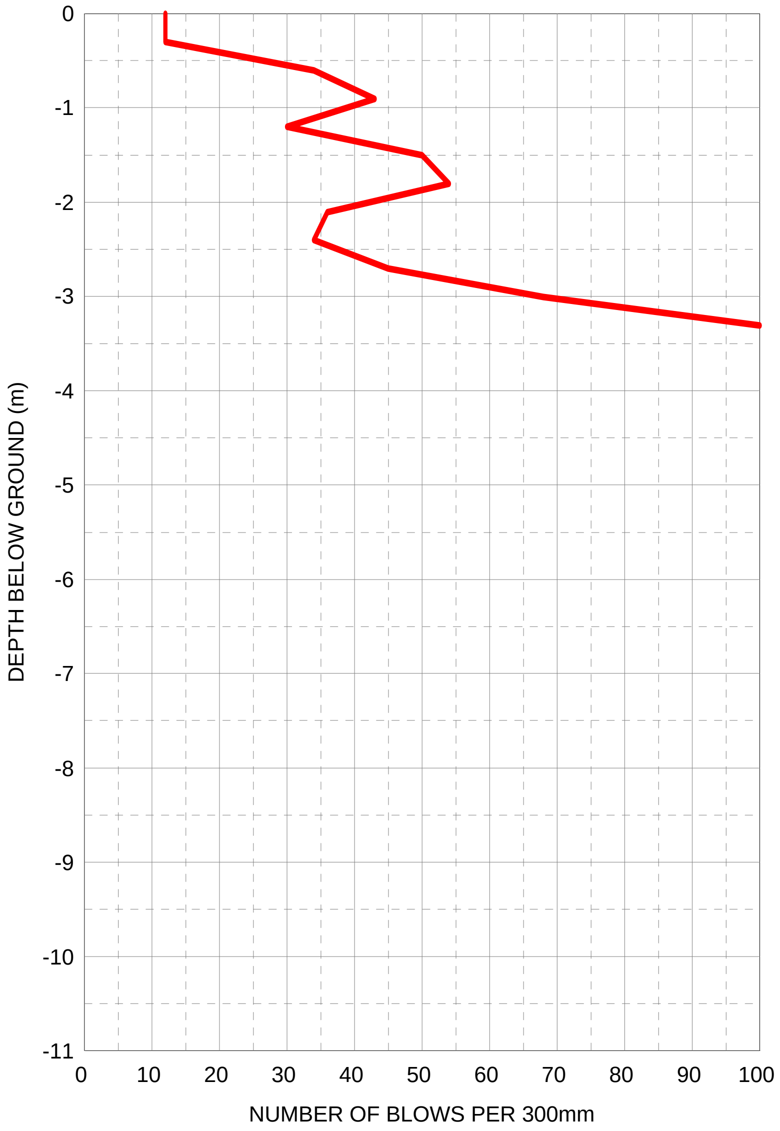
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 28
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	12
0.6	34
0.9	43
1.2	30
1.5	50
1.8	54
2.1	36
2.4	34
2.7	45
3.0	68
3.3	100
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

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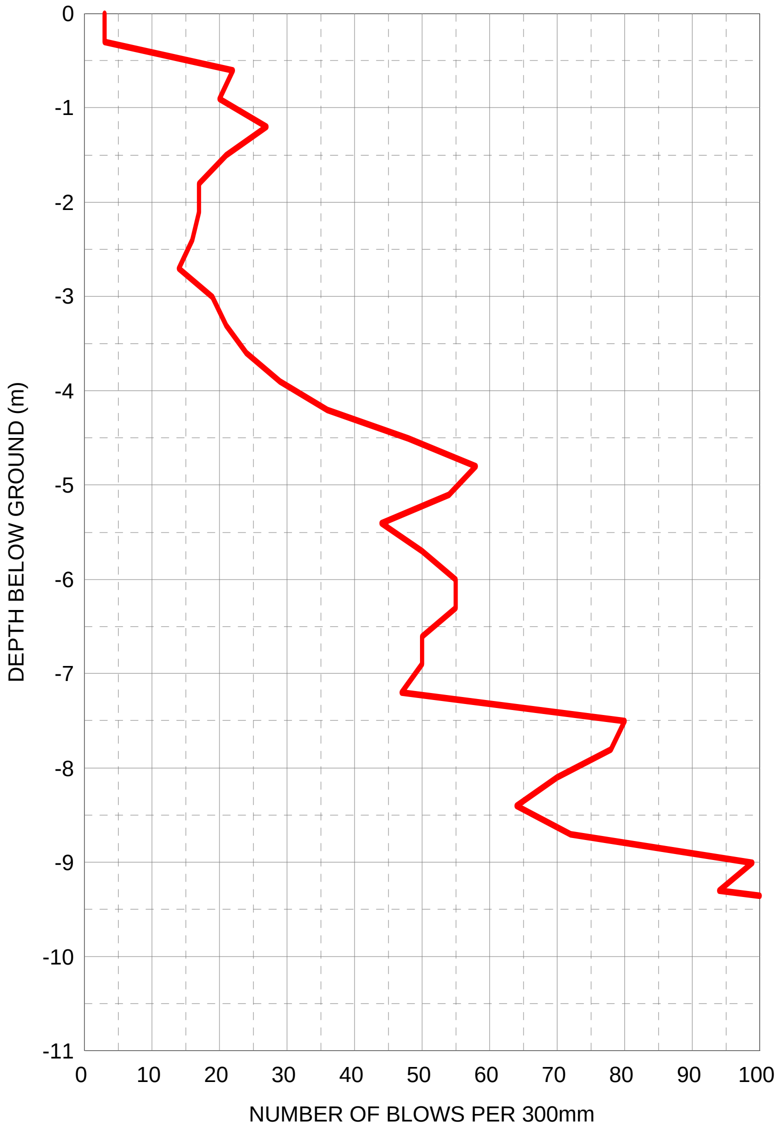
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 29
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	22
0.9	20
1.2	27
1.5	21
1.8	17
2.1	17
2.4	16
2.7	14
3.0	19
3.3	21
3.6	24
3.9	29
4.2	36
4.5	48
4.8	58
5.1	54
5.4	44
5.7	50
6.0	55
6.3	55
6.6	50
6.9	50
7.2	47
7.5	80
7.8	78
8.1	70
8.4	64
8.7	72
9.0	99
9.3	94
9.6	127
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

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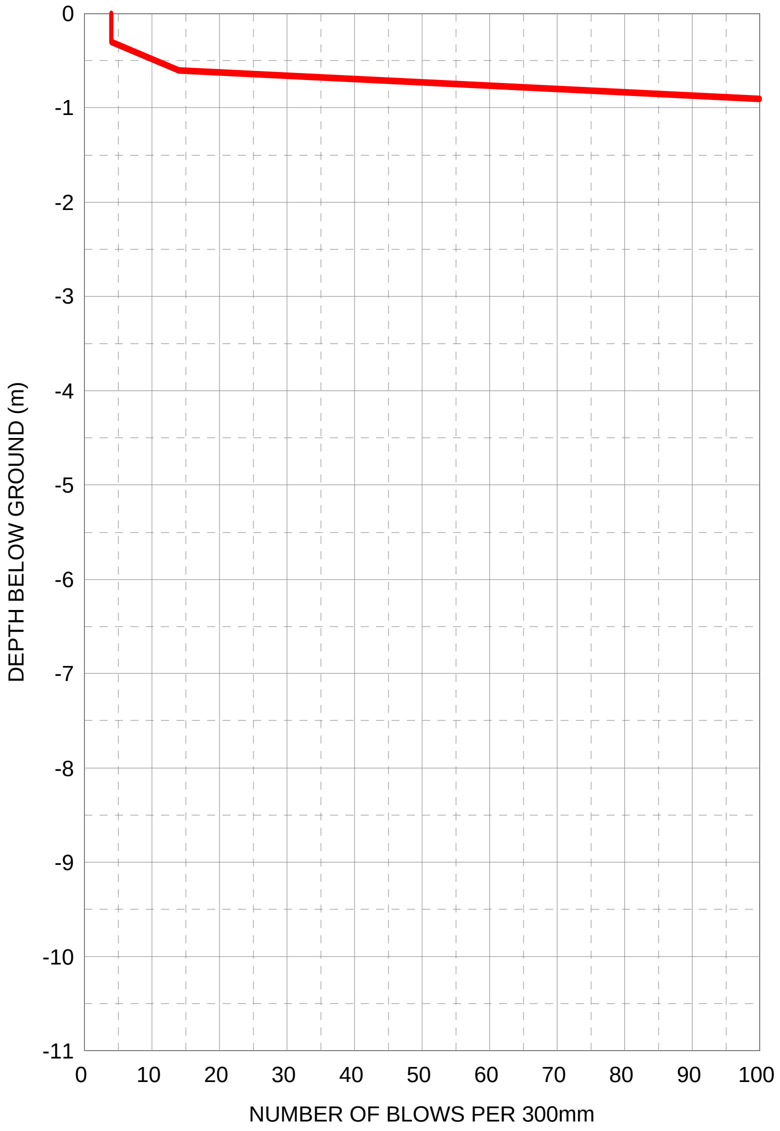
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 30
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	4
0.6	14
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

GEOPRACTICA
SOILS & MATERIALS TESTING
P.O.BOX 227, MARAISBURG, 1700
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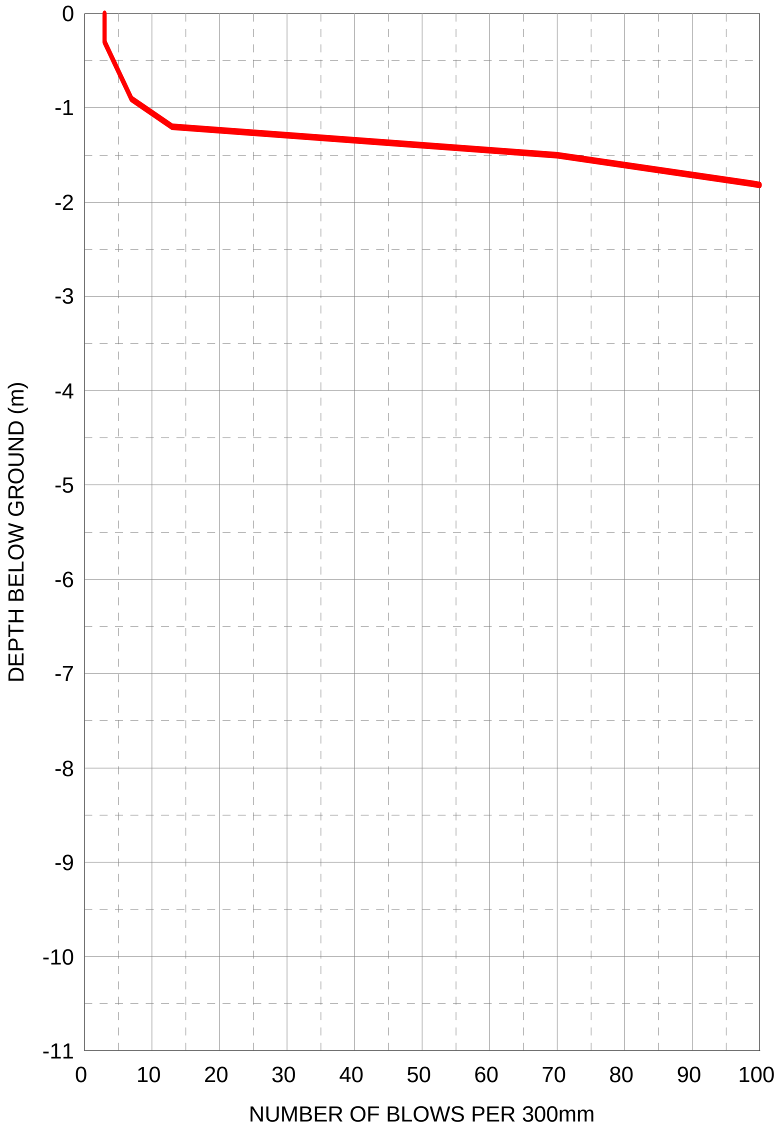
e mail: lab@geopractica.co.za

DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 31 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	5
0.9	7
1.2	13
1.5	70
1.8	99
2.1	116
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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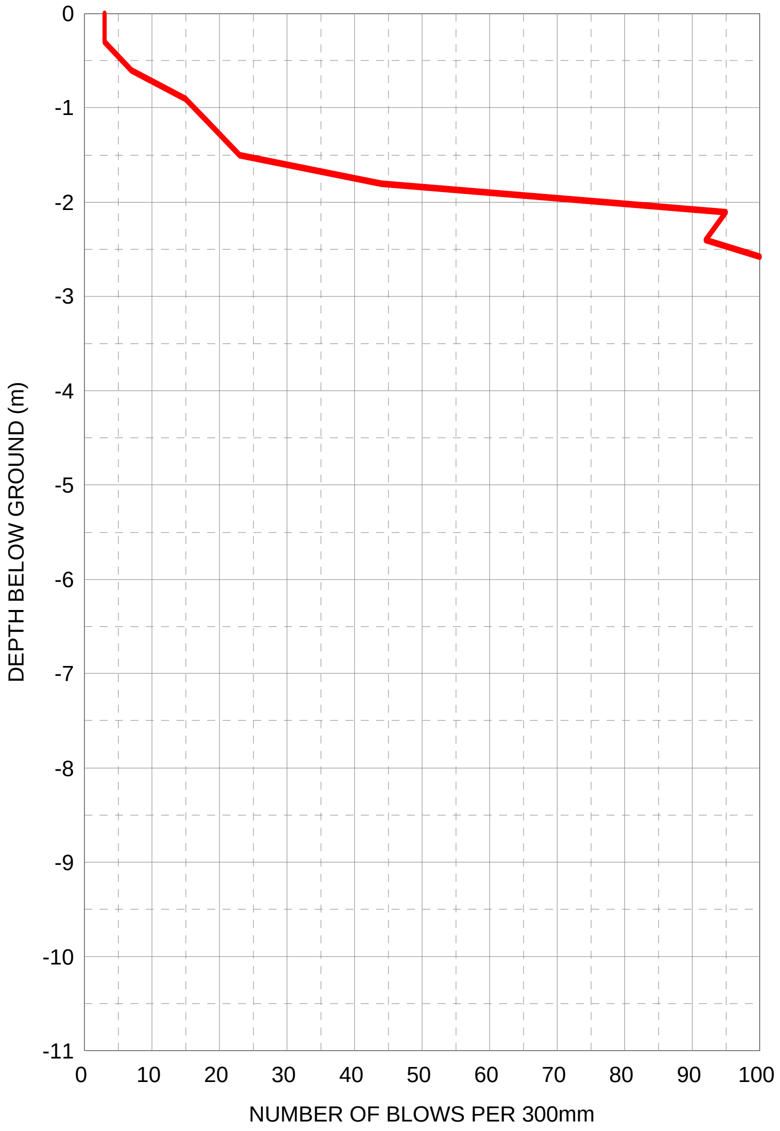
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 31 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	7
0.9	15
1.2	19
1.5	23
1.8	44
2.1	95
2.4	92
2.7	106
3.0	118
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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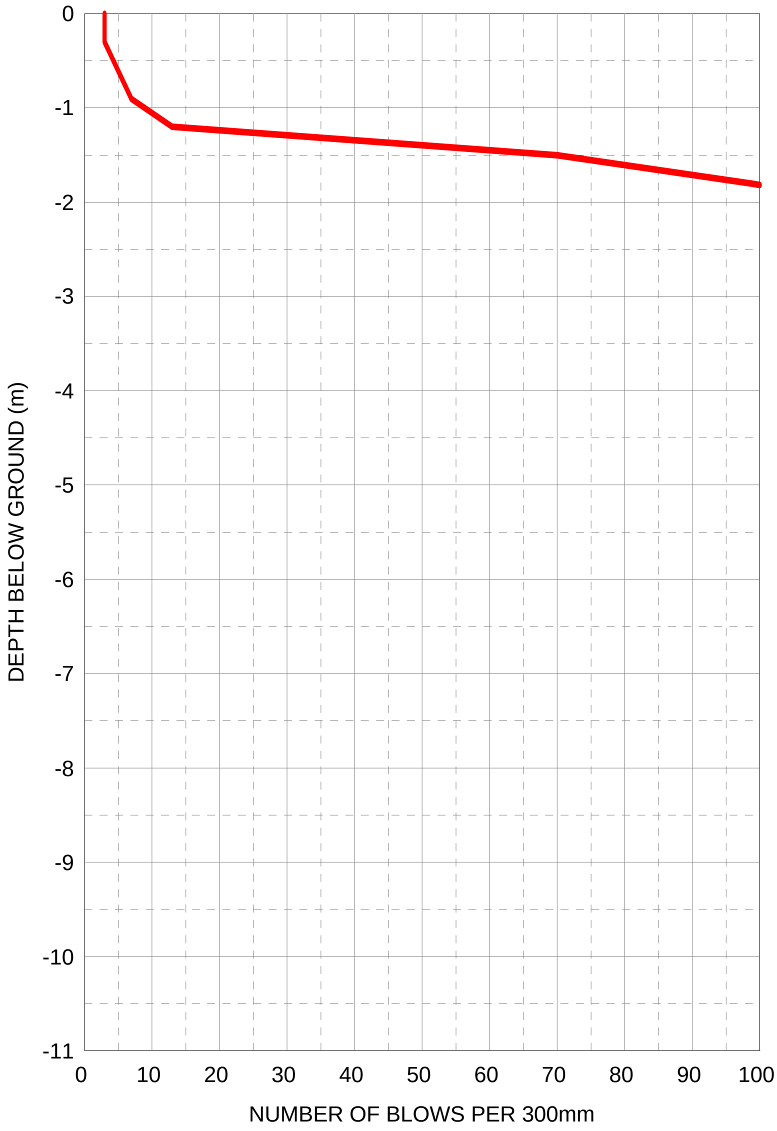
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 31 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	5
0.9	7
1.2	13
1.5	70
1.8	99
2.1	116
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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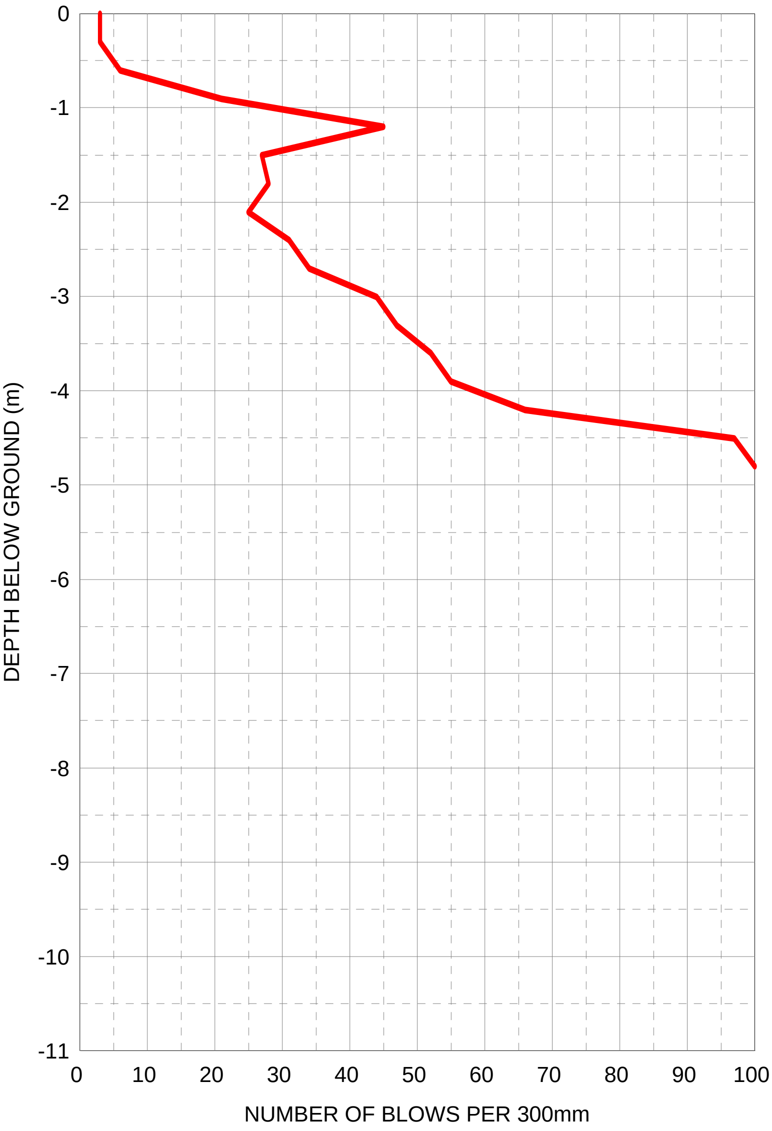
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 32
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	6
0.9	21
1.2	45
1.5	27
1.8	28
2.1	25
2.4	31
2.7	34
3.0	44
3.3	47
3.6	52
3.9	55
4.2	66
4.5	97
4.8	100
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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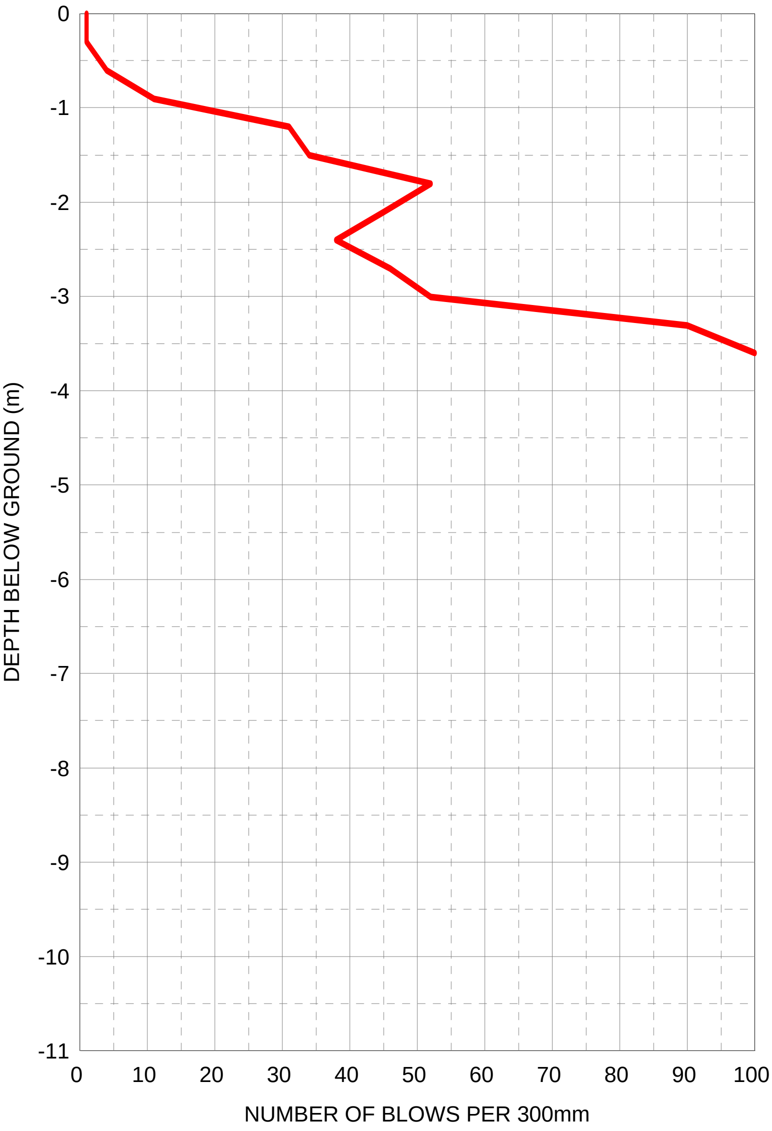
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 33
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	11
1.2	31
1.5	34
1.8	52
2.1	45
2.4	38
2.7	46
3.0	52
3.3	90
3.6	100
3.9	113
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
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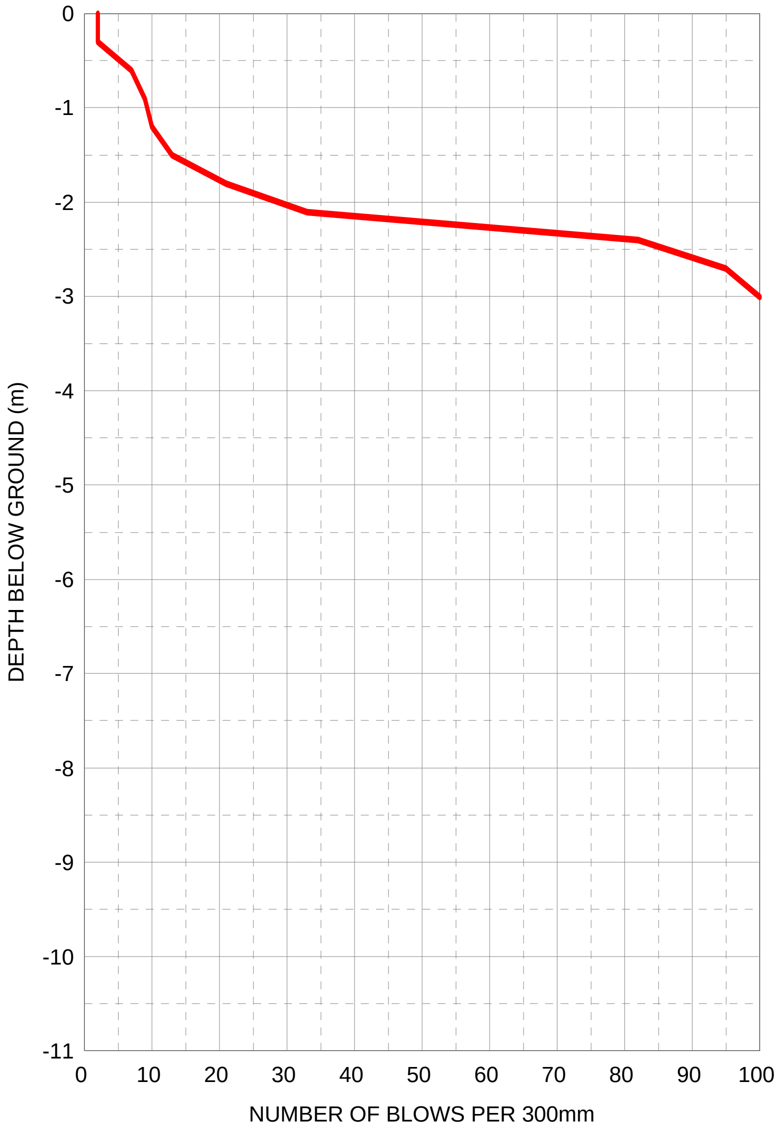
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 34
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	7
0.9	9
1.2	10
1.5	13
1.8	21
2.1	33
2.4	82
2.7	95
3.0	100
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
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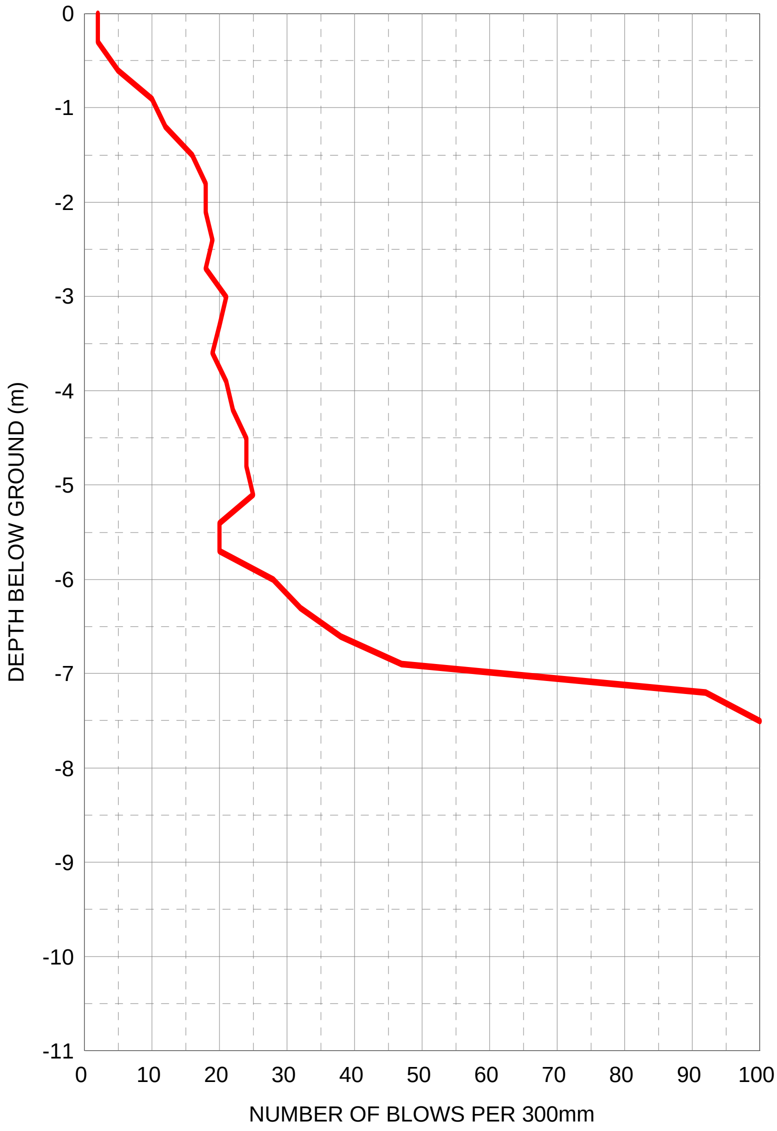
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 35
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	5
0.9	10
1.2	12
1.5	16
1.8	18
2.1	18
2.4	19
2.7	18
3.0	21
3.3	20
3.6	19
3.9	21
4.2	22
4.5	24
4.8	24
5.1	25
5.4	20
5.7	20
6.0	28
6.3	32
6.6	38
6.9	47
7.2	92
7.5	100
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	1	Blows

Programe Data
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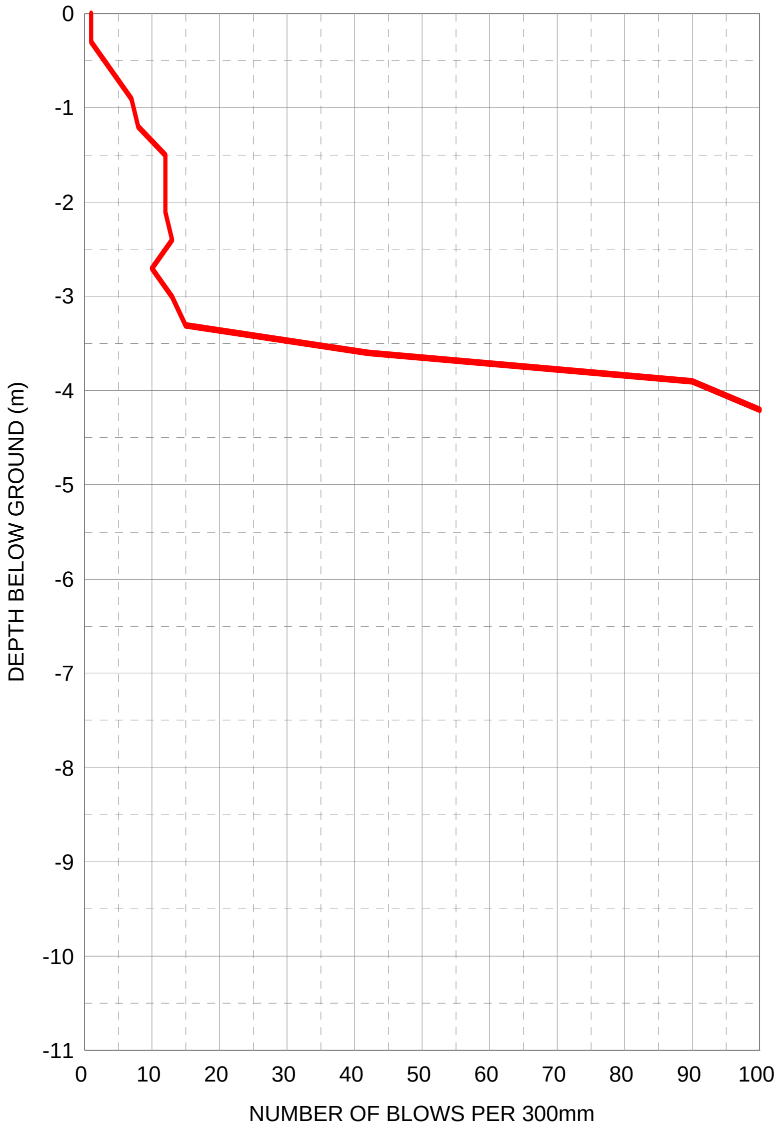
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 36
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	7
1.2	8
1.5	12
1.8	12
2.1	12
2.4	13
2.7	10
3.0	13
3.3	15
3.6	42
3.9	90
4.2	100
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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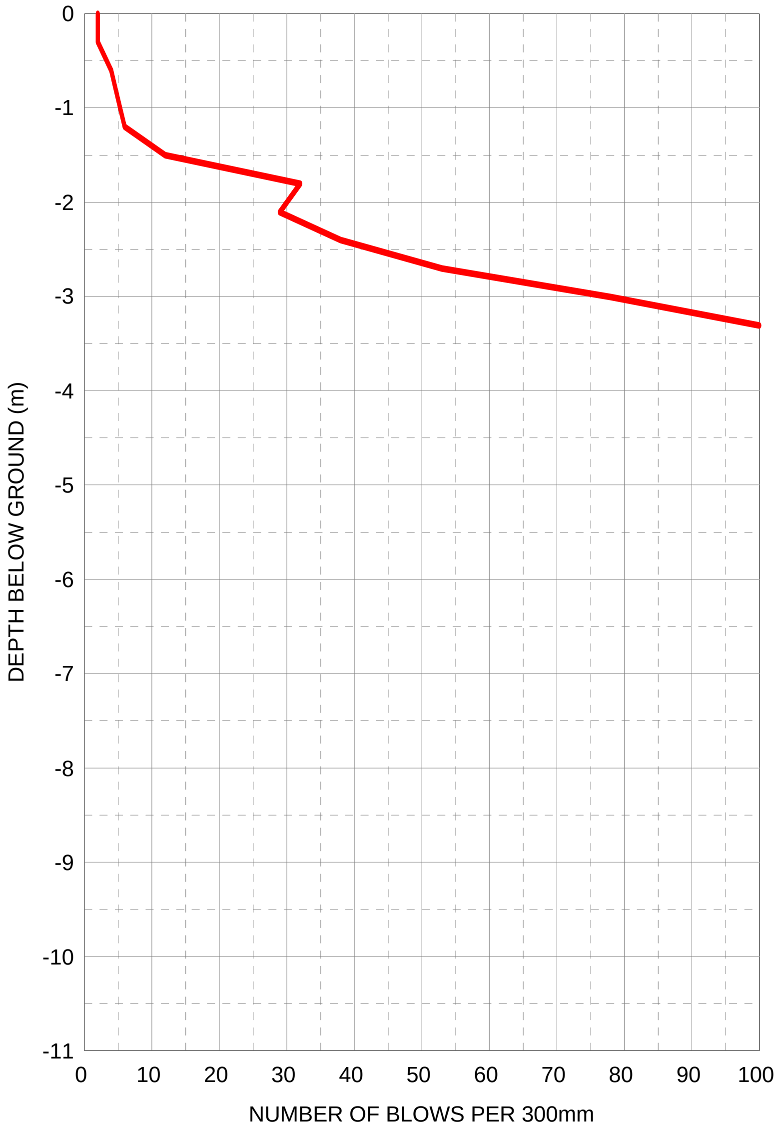
e mail: lab@geopractica.co.za

DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 37
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	5
1.2	6
1.5	12
1.8	32
2.1	29
2.4	38
2.7	53
3.0	78
3.3	100
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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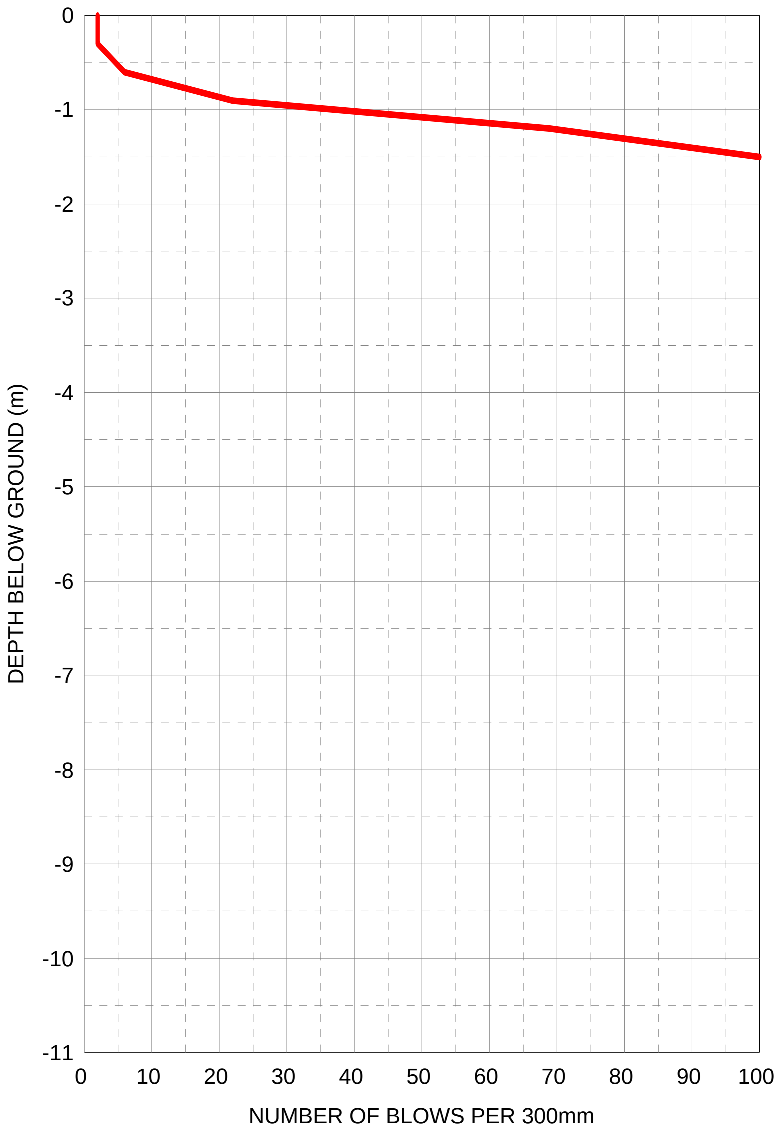
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 38
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	6
0.9	22
1.2	69
1.5	100
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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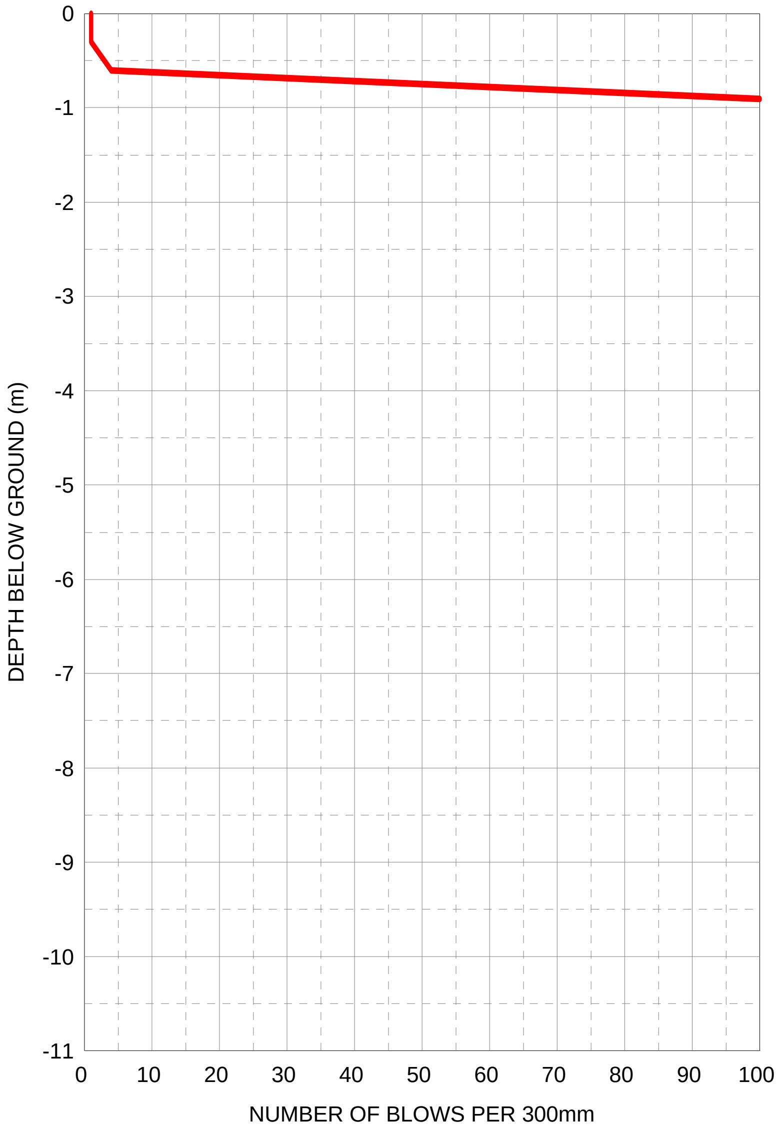
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 39 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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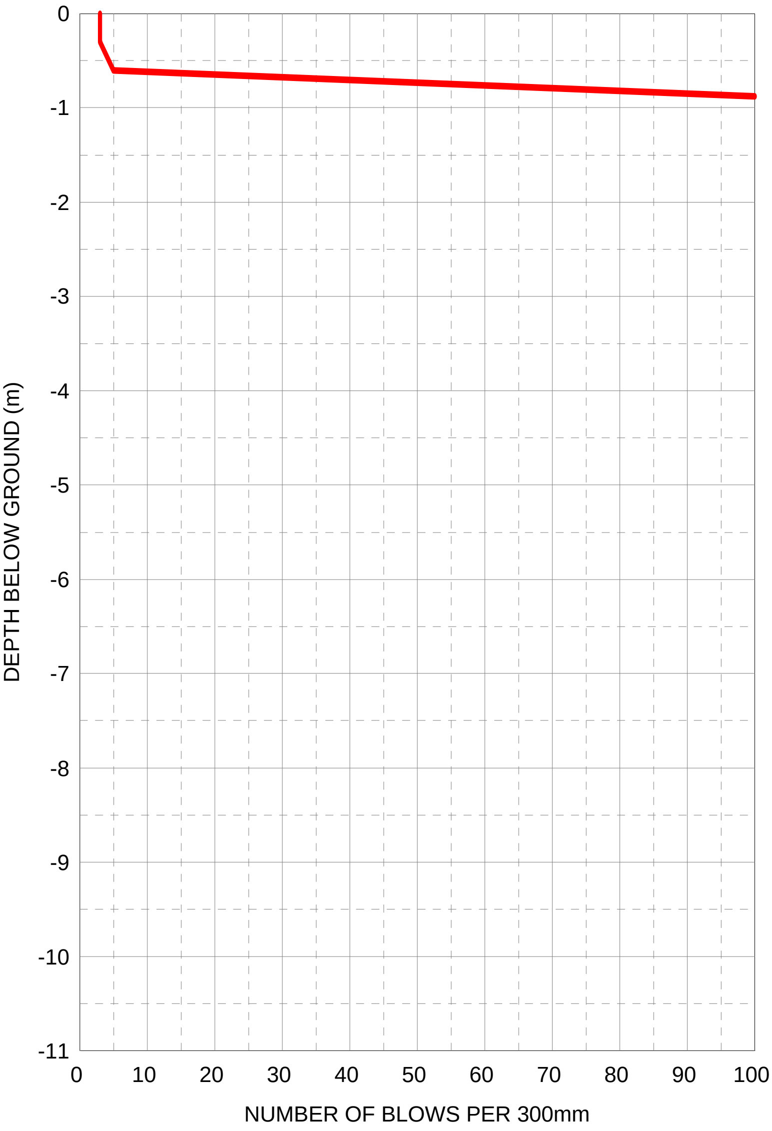
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 39 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	5
0.9	110
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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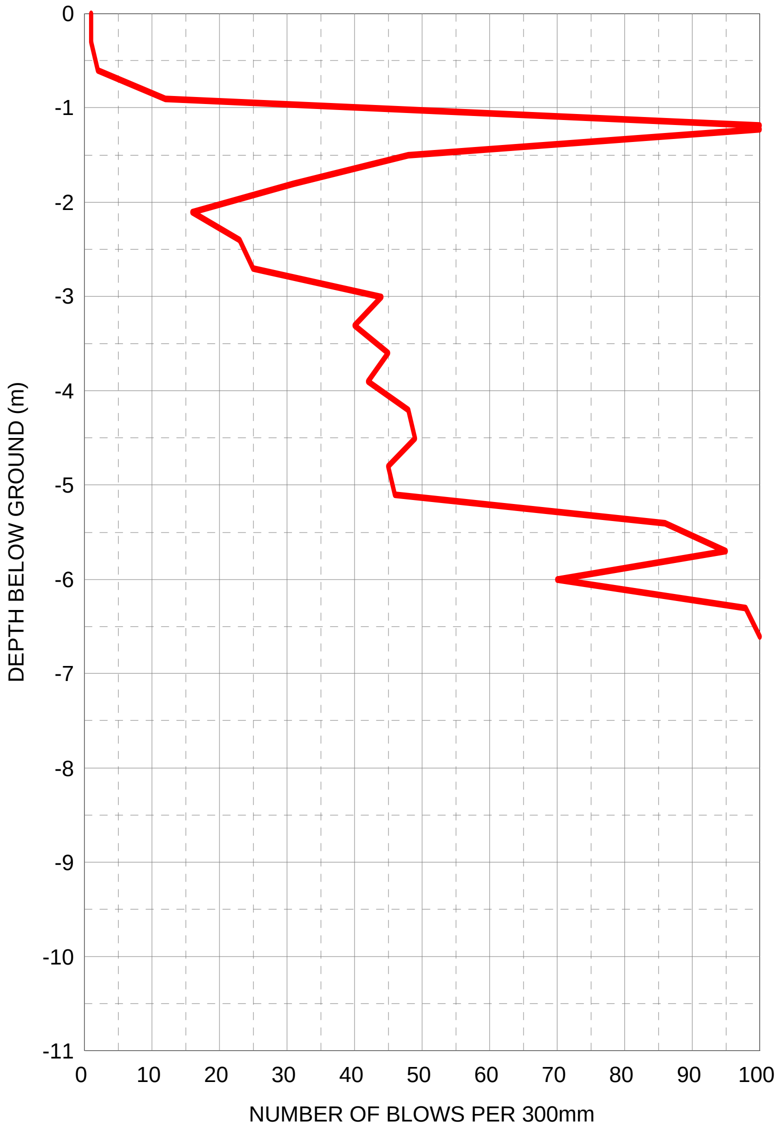
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 40
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	2
0.9	12
1.2	105
1.5	48
1.8	31
2.1	16
2.4	23
2.7	25
3.0	44
3.3	40
3.6	45
3.9	42
4.2	48
4.5	49
4.8	45
5.1	46
5.4	86
5.7	95
6.0	70
6.3	98
6.6	100
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 41
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	7
1.2	22
1.5	47
1.8	46
2.1	37
2.4	35
2.7	47
3.0	48
3.3	45
3.6	50
3.9	43
4.2	43
4.5	65
4.8	46
5.1	63
5.4	100
5.7	130
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
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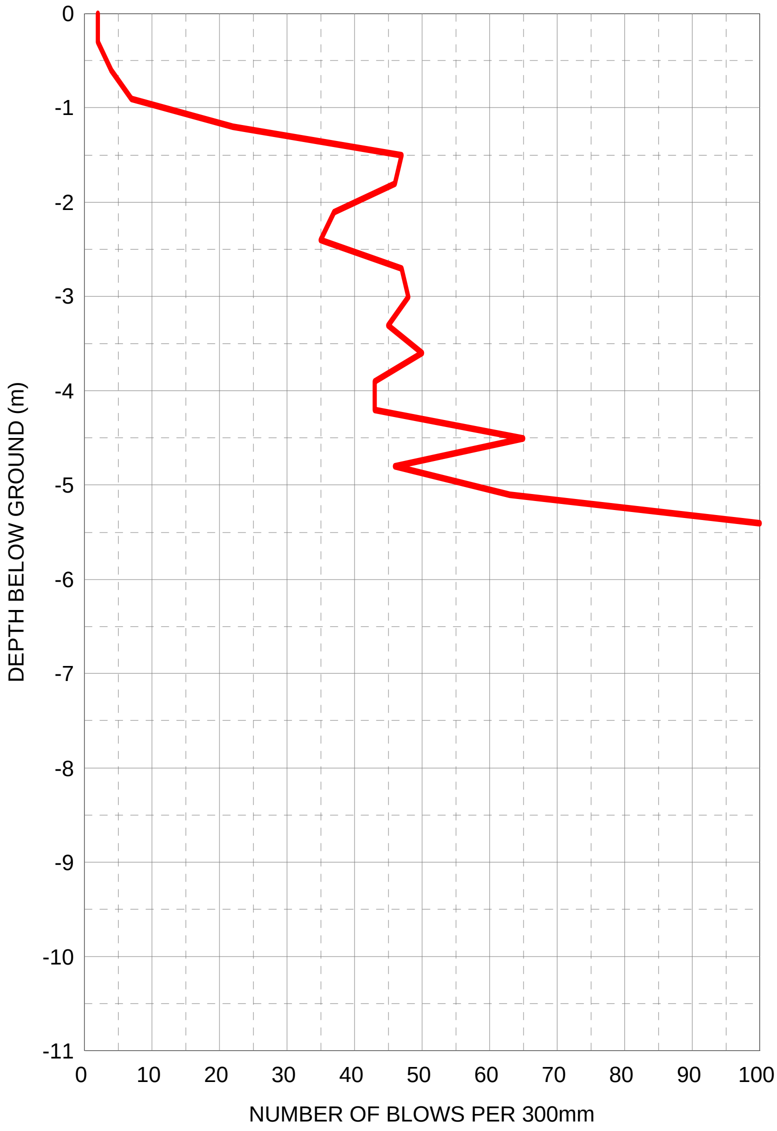
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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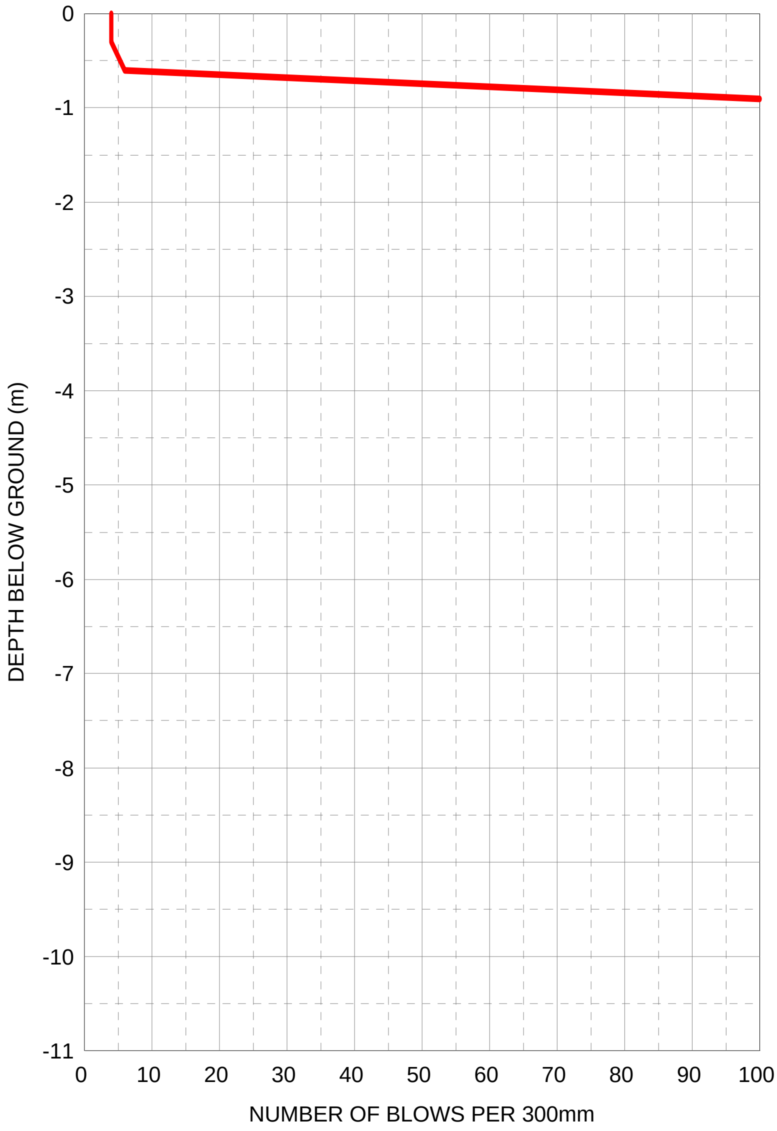
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 42 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	4
0.6	6
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

GEOPRACTICA
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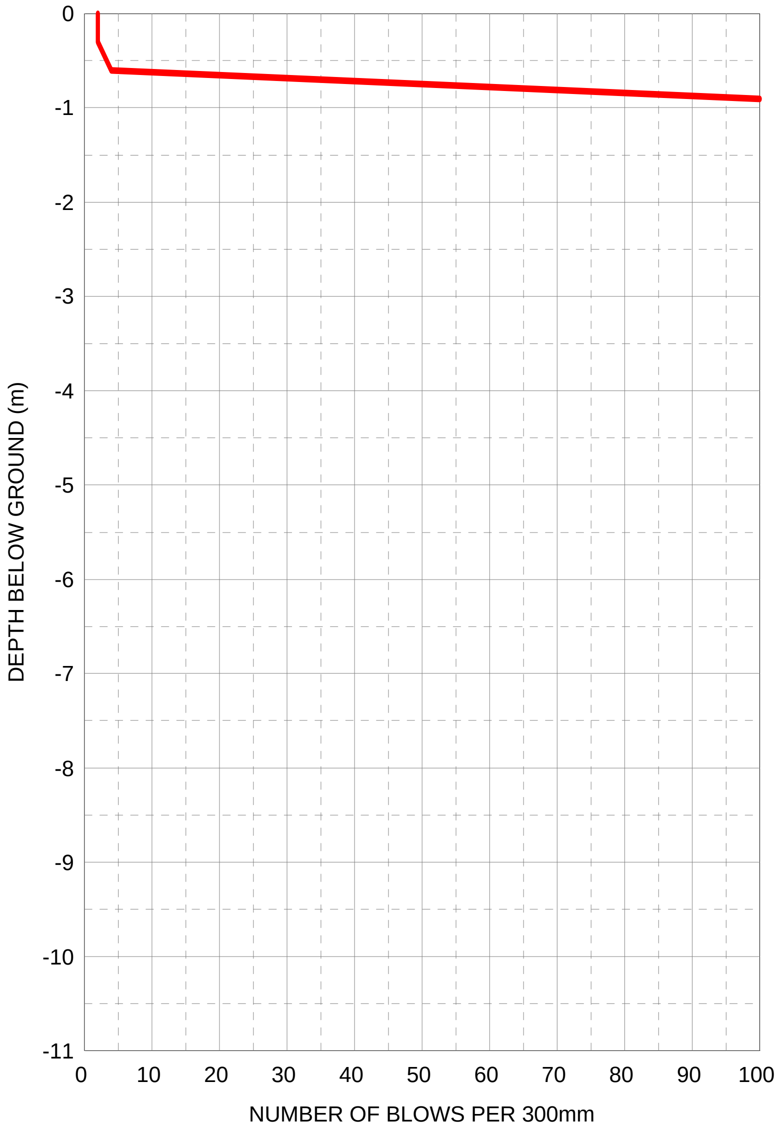
FAX: (011) 674 4513
e mail: lab@geopractica.co.za

DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 42 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	100
1.2	
1.5	
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
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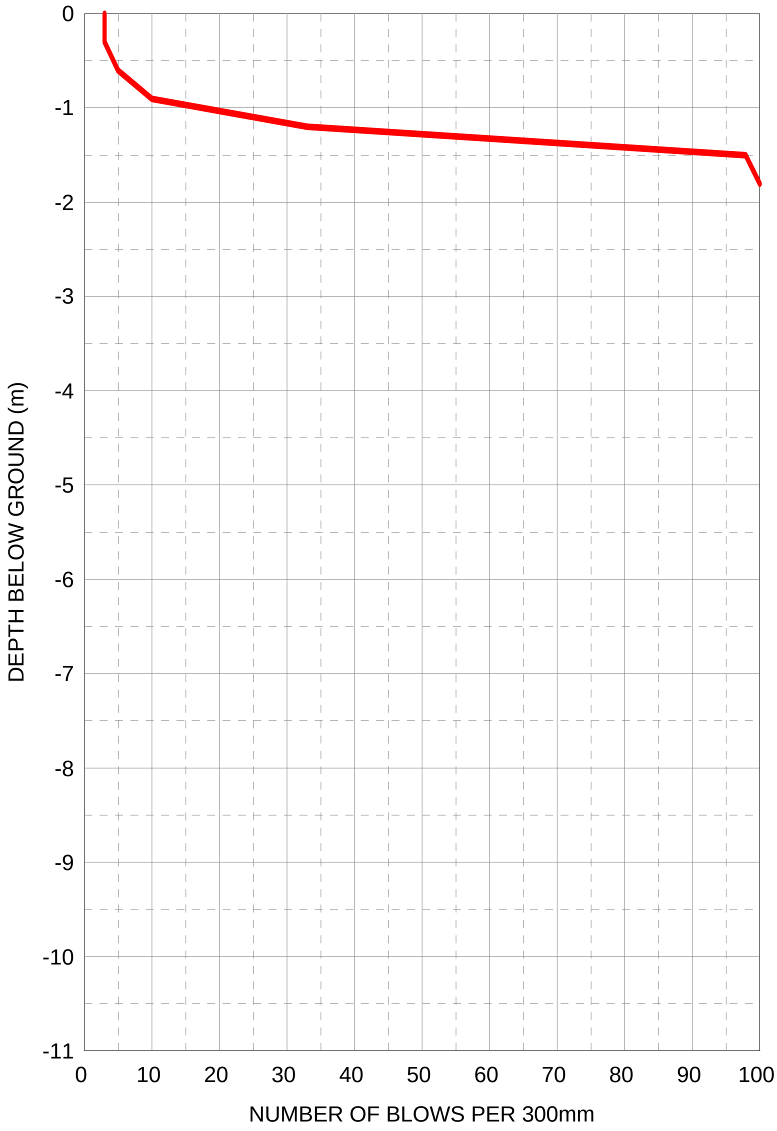
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 43 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	5
0.9	10
1.2	33
1.5	98
1.8	100
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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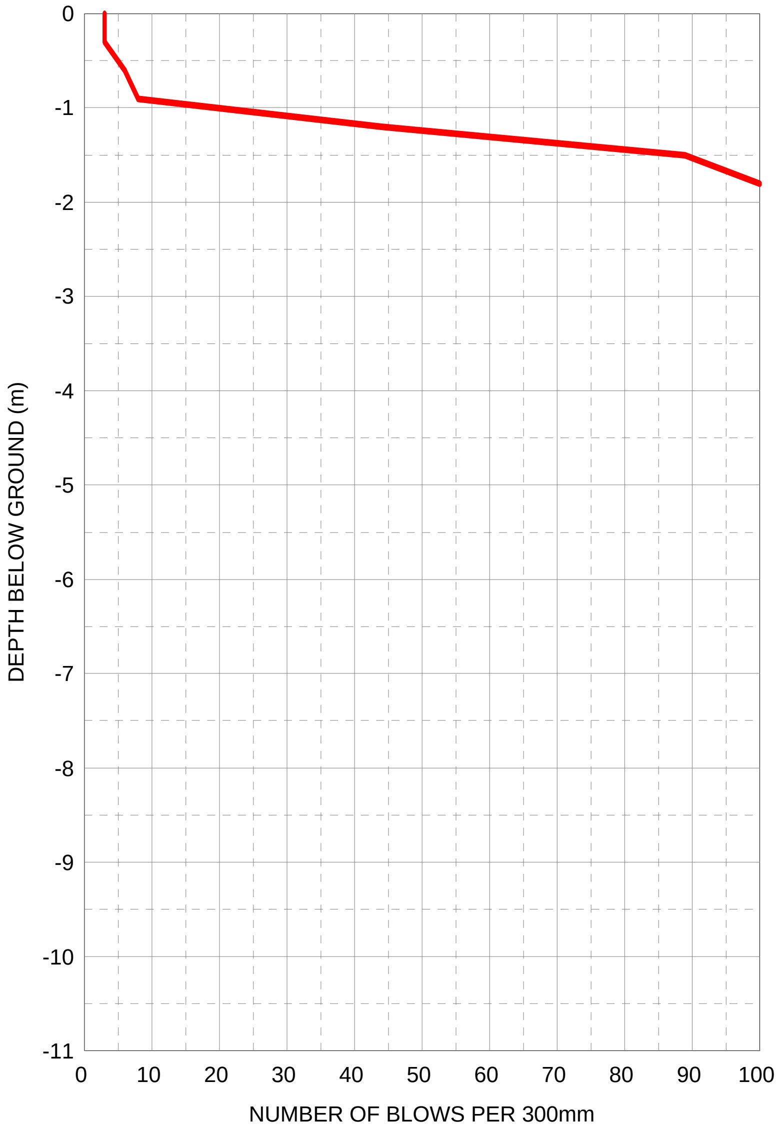
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 43 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	6
0.9	8
1.2	44
1.5	89
1.8	100
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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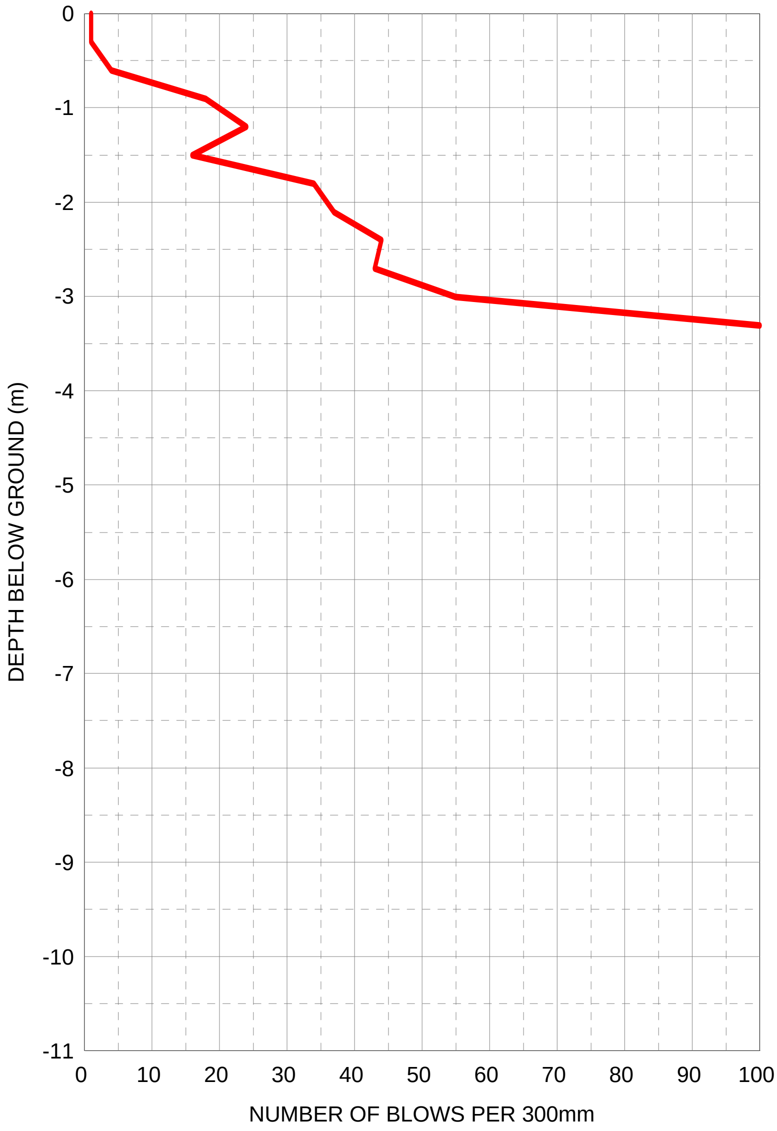
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 44
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	4
0.9	18
1.2	24
1.5	16
1.8	34
2.1	37
2.4	44
2.7	43
3.0	55
3.3	100
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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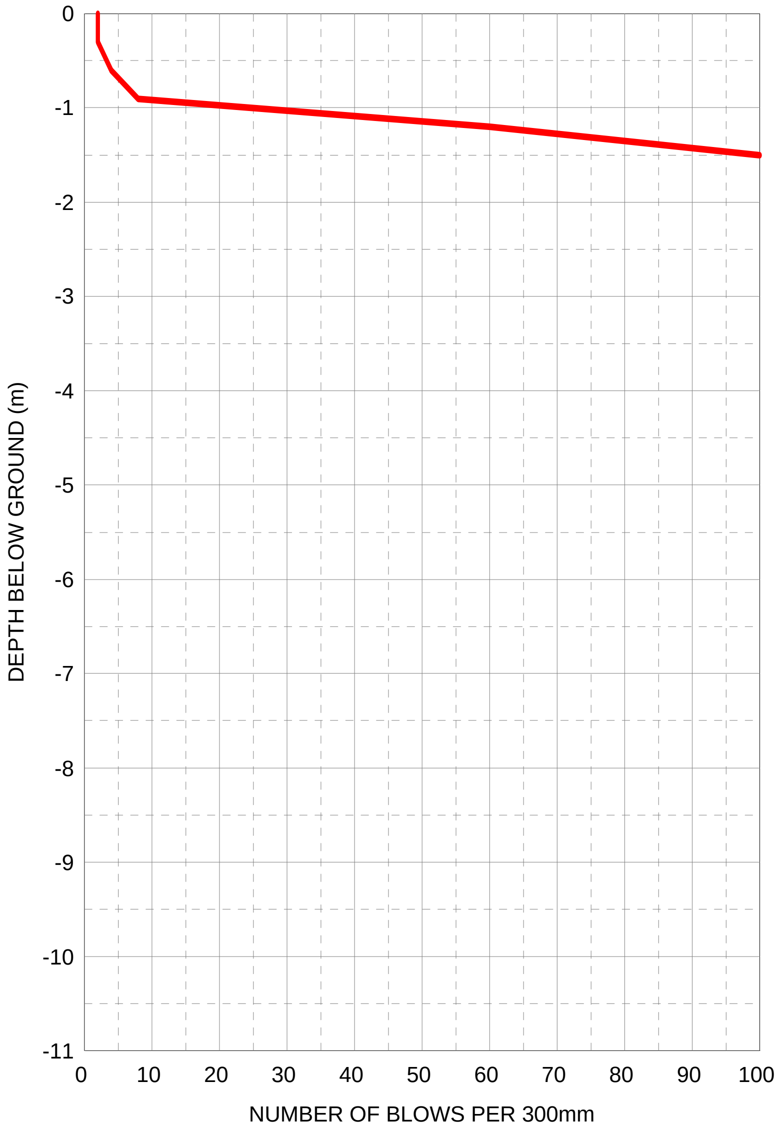
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 45 (A)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	8
1.2	60
1.5	100
1.8	
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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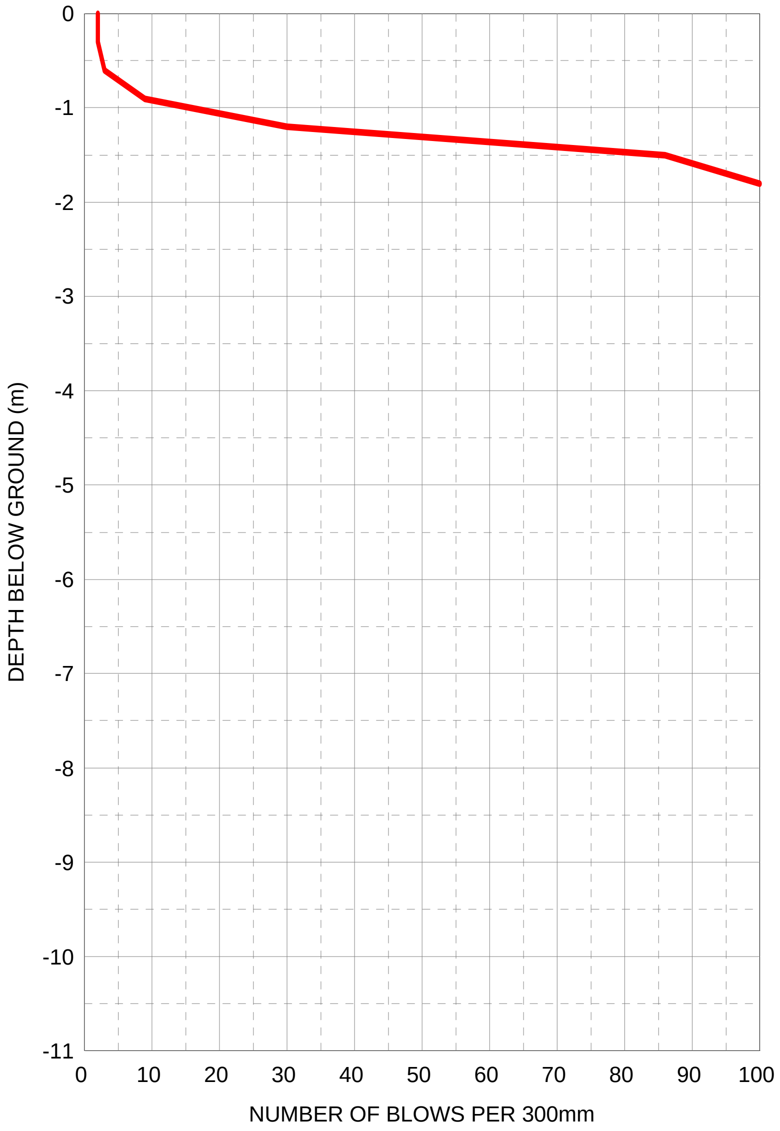
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 45 (B)
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	3
0.9	9
1.2	30
1.5	86
1.8	100
2.1	
2.4	
2.7	
3.0	
3.3	
3.6	
3.9	
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm		Blows

Programe Data
Revision No 2 (19/04/2002)

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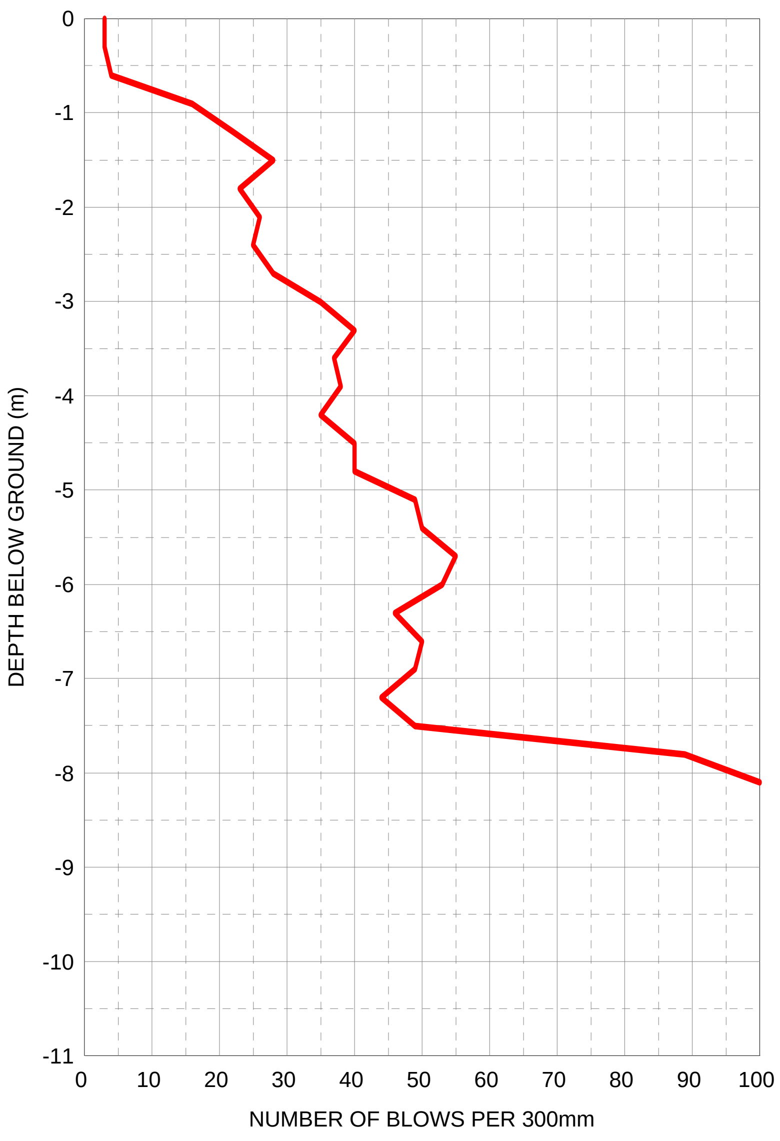
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 46
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	3
0.6	4
0.9	16
1.2	22
1.5	28
1.8	23
2.1	26
2.4	25
2.7	28
3.0	35
3.3	40
3.6	37
3.9	38
4.2	35
4.5	40
4.8	40
5.1	49
5.4	50
5.7	55
6.0	53
6.3	46
6.6	50
6.9	49
7.2	44
7.5	49
7.8	89
8.1	100
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	1	Blows

Programe Data
Revision No 2 (19/04/2002)

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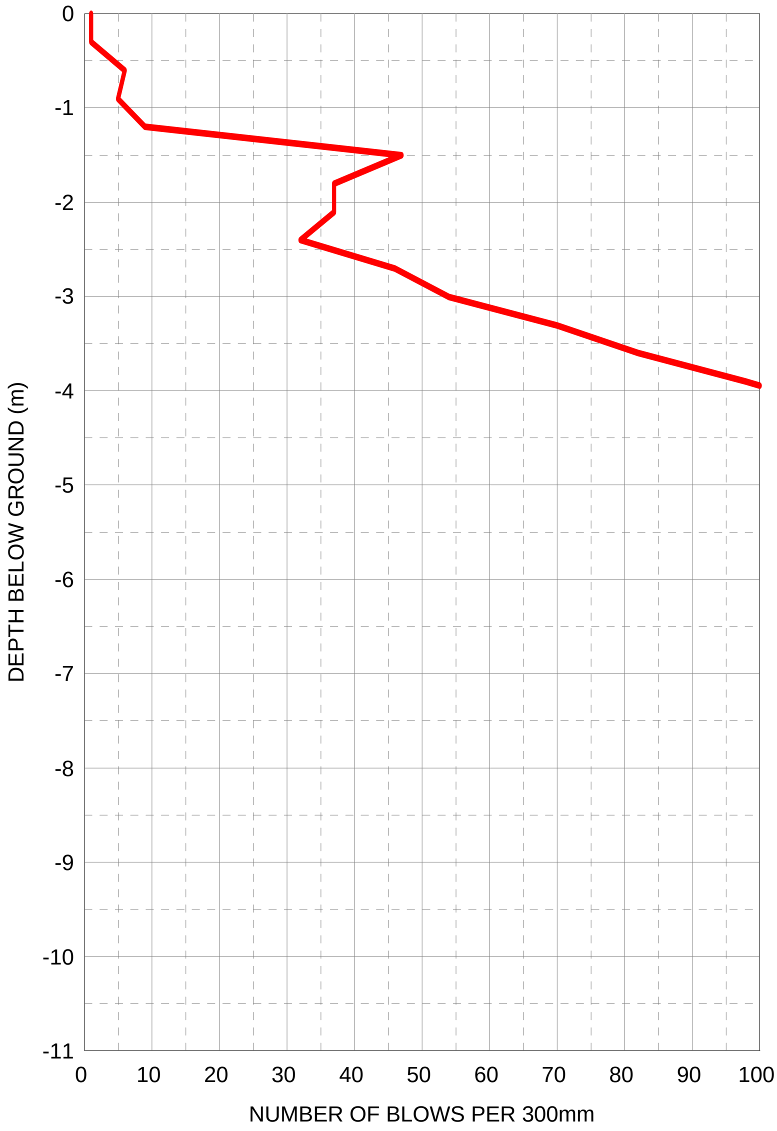
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 47
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	6
0.9	5
1.2	9
1.5	47
1.8	37
2.1	37
2.4	32
2.7	46
3.0	54
3.3	70
3.6	82
3.9	98
4.2	112
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	1	Blows

Programe Data
Revision No 2 (19/04/2002)

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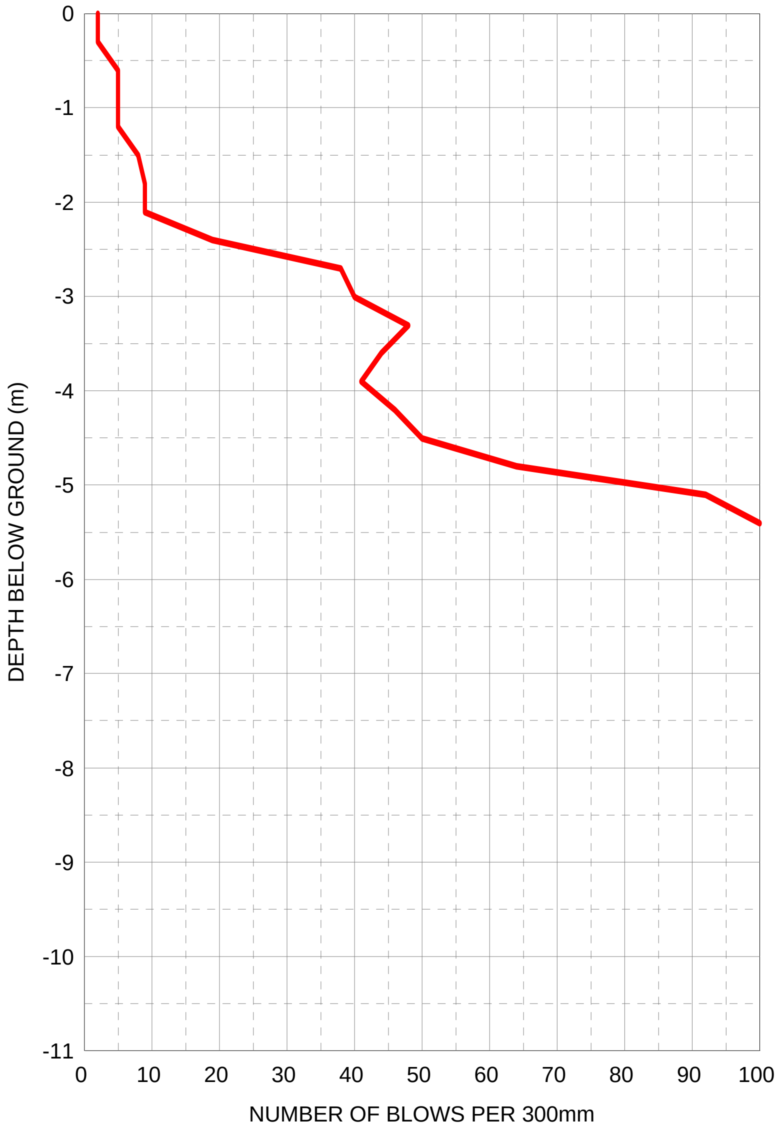
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH 48
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	5
0.9	5
1.2	5
1.5	8
1.8	9
2.1	9
2.4	19
2.7	38
3.0	40
3.3	48
3.6	44
3.9	41
4.2	46
4.5	50
4.8	64
5.1	92
5.4	100
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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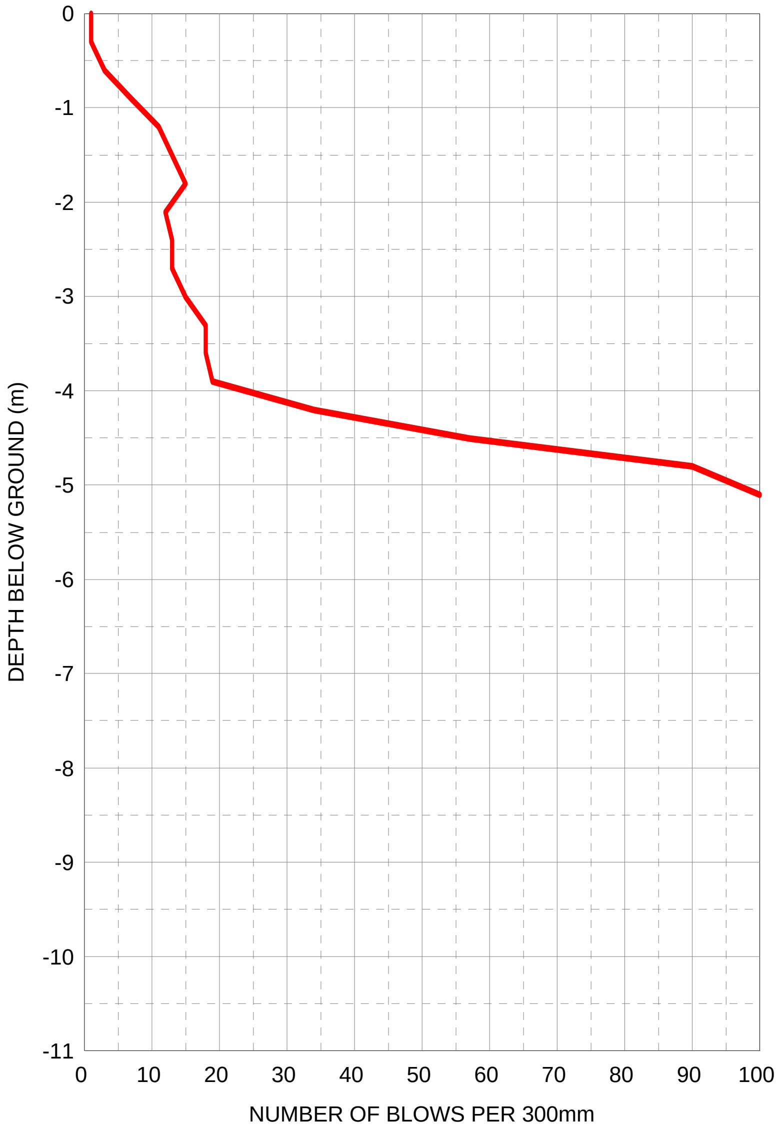
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 49
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	1
0.6	3
0.9	7
1.2	11
1.5	13
1.8	15
2.1	12
2.4	13
2.7	13
3.0	15
3.3	18
3.6	18
3.9	19
4.2	34
4.5	57
4.8	90
5.1	100
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	0	Blows

Programe Data
Revision No 2 (19/04/2002)

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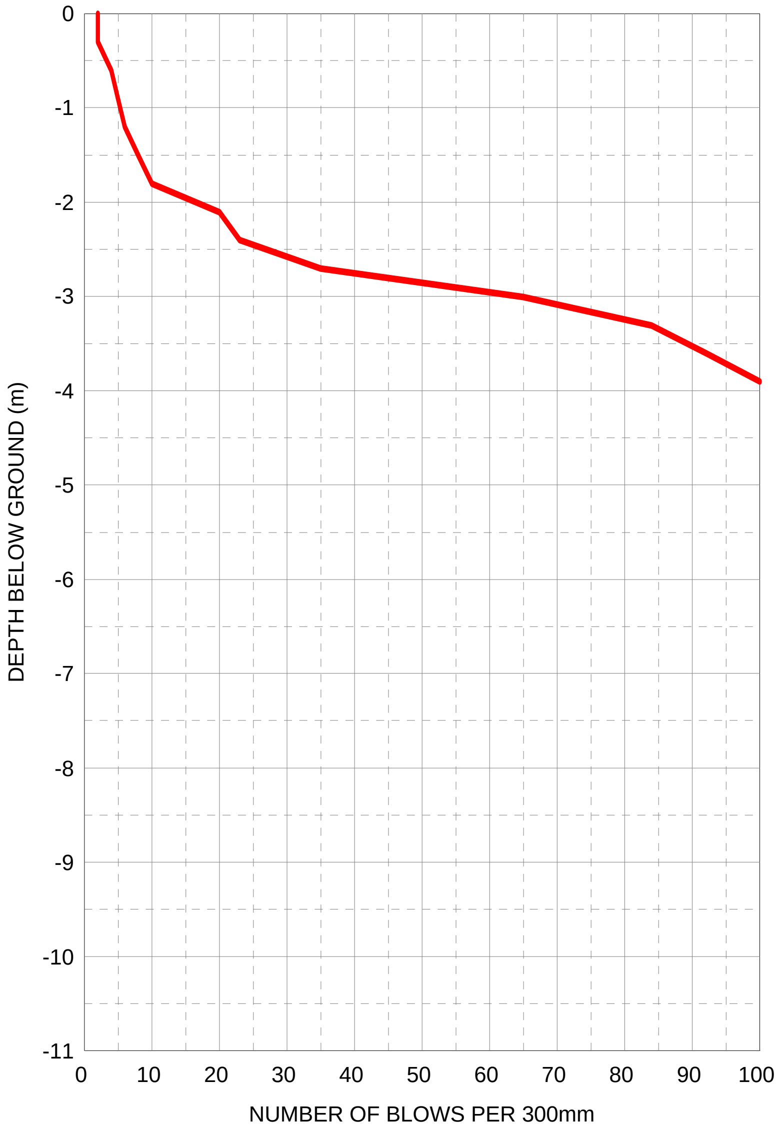
DYNAMIC CONE PENETROMETER (DPSH)

Client	RWBE GEOTECHNICAL DRILLING		
Location	KOEKENAAP		
Date	20 JULY 2010	Test No	DPSH - WTG 50
Job No	10174	Checked By	EB

DEPTH (m)	BLOWS PER 300mm
0.0	0
0.3	2
0.6	4
0.9	5
1.2	6
1.5	8
1.8	10
2.1	20
2.4	23
2.7	35
3.0	65
3.3	84
3.6	92
3.9	100
4.2	
4.5	
4.8	
5.1	
5.4	
5.7	
6.0	
6.3	
6.6	
6.9	
7.2	
7.5	
7.8	
8.1	
8.4	
8.7	
9.0	
9.3	
9.6	
9.9	
10.2	
10.5	
10.8	
11.1	



RE-DRIVE LAST 300mm	1	Blows

Programe Data
Revision No 2 (19/04/2002)

APPENDIX G:

PLATE LOAD TEST RESULTS

GEOPRACTICA
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P.O.BOX 227, MARAISBURG, 1700

TEL: (011) 674 1325
FAX: (011) 674 4513
e mail: lab@geopractica.co.za

PLATE JACKING TEST - VERTICAL

Client	RWBE		
Location	Koekenaaps Site PLT. WTG 4a (2.1m)		
Date	4th August 2010	Test No	9A
Job No	10174	Checked By	CD

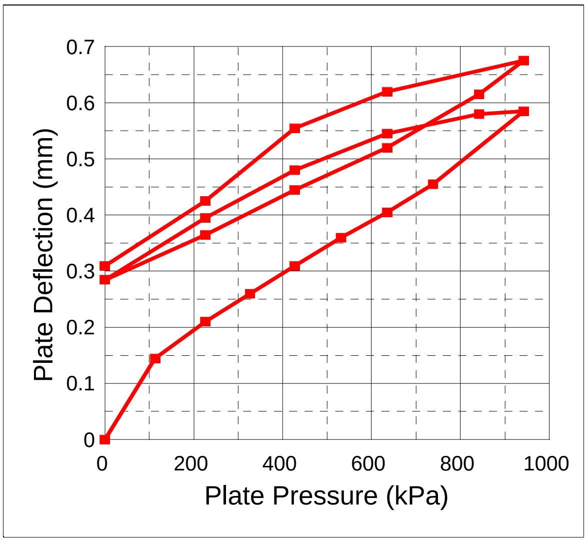
Direction of Test	Vertical		Plate Diameter (mm)	450.00	
Jack Number	490		Ram Diameter (mm)	65.00	
Gauge No:	80MPa	Calibration Cert No.	2178	Calibration Date	2 sept 2010

Direct Readings & Analysis

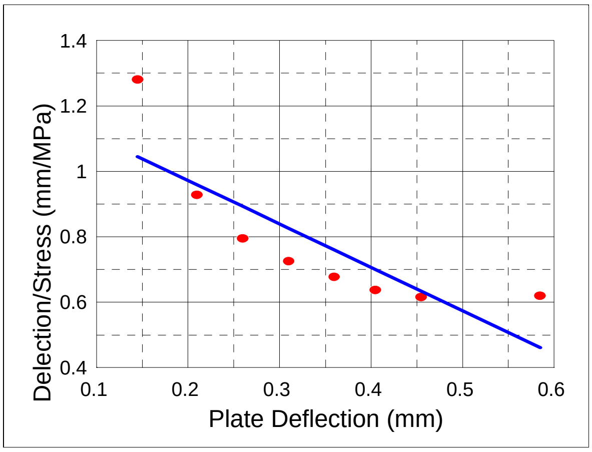
Gauge Pressure (MPa)	Ram Load (kN)	Plate Stress (kPa)	Plate Defln (mm)	Incremental Value of E (MPa)	Average Value of E (MPa)
0	0.0	0	0.00	0.00	0
5	18.0	113	0.15	**258.62**	**258.62**
10	36.0	226	0.21	**576.92**	**357.14**
15	52.0	327	0.26	**666.67**	**416.67**
20	68.0	428	0.31	**666.67**	**456.99**
25	84.5	531	0.36	**687.50**	**489.00**
30	101.0	635	0.41	**763.89**	**519.55**
35	117.5	739	0.46	**687.50**	**538.00**
45	150.0	943	0.59	**520.83**	**534.19**
40	134.0	843	0.58		
30	101.0	635	0.55		
20	68.0	428	0.48		
10	36.0	226	0.40		
0	0.0	0	0.29		
10	36.0	226	0.37		
20	68.0	428	0.45		
30	101.0	635	0.52		
40	134.0	843	0.62		
45	150.0	943	0.68		
30	101.0	635	0.62		
20	68.0	428	0.56		
10	36.0	226	0.43		
0	0.0	0	0.31		
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			

Hyperbolic Transformation value of E (MPa)	**172.68**

Graphical Representation of Stress/Strain



Hyperbolic Representation



Programe Data
Revision No 3 (30/08/2010)

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e mail: lab@geopractica.co.za

PLATE JACKING TEST - HORIZONTAL

Client	RWBE		
Location	Koekenaaps Site PLT. WTG 4b (2.5m)		
Date	5th August 2010	Test No	10A
Job No	10174	Checked By	CD

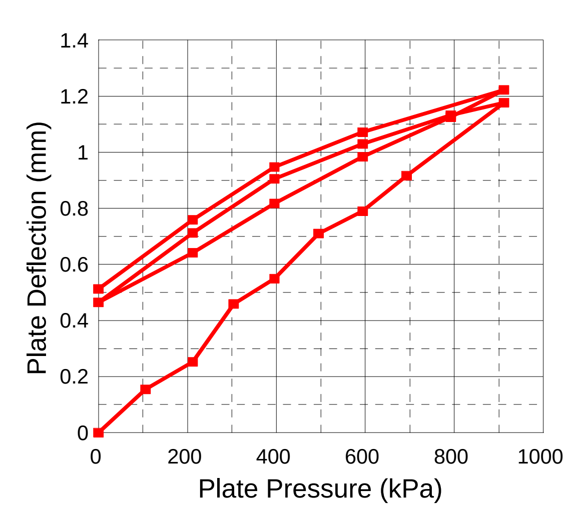
Direction of Test	Horizontal		Plate Diameter (mm)	300.00	
Jack Number	C106		Ram Diameter (mm)	42.82	
Gauge No:	80MPa	Calibration Cert No.	2177	Calibration Date	2 sept 2010

Direct Readings & Analysis

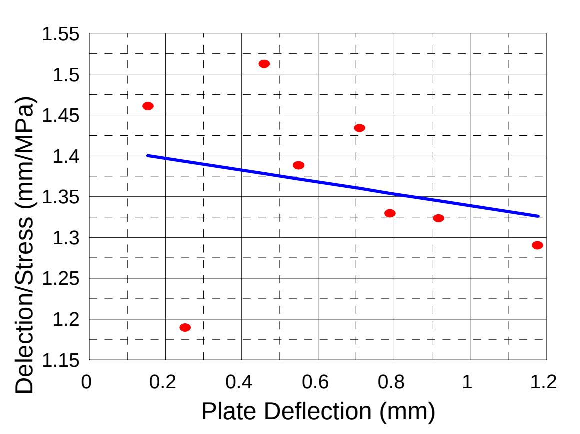
Gauge Pressure (MPa)	Ram Load (kN)	Plate Stress (kPa)	Plate Defln (mm)	Incremental Value of E (MPa)	Average Value of E (MPa)
0	0.0	0	0.00	0.00	0
5	7.5	106	0.16	**151.21**	**151.21**
10	15.0	212	0.25	**240.38**	**185.64**
15	21.5	304	0.46	**97.89**	**146.06**
20	28.0	396	0.55	**225.69**	**159.09**
25	35.0	495	0.71	**136.72**	**154.05**
30	42.0	594	0.79	**273.44**	**166.14**
35	49.0	693	0.92	**171.57**	**166.89**
45	64.5	912	1.18	**186.30**	**171.18**
40	56.0	792	1.13		
30	42.0	594	1.03		
20	28.0	396	0.91		
10	15.0	212	0.71		
0	0.0	0	0.47		
10	15.0	212	0.64		
20	28.0	396	0.82		
30	42.0	594	0.99		
40	56.0	792	1.13		
45	64.5	912	1.22		
30	42.0	594	1.07		
20	28.0	396	0.95		
10	15.0	212	0.76		
0	0.0	0	0.51		
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			
	0.0	0			

Hyperbolic Transformation value of E (MPa)	**100.96**

Graphical Representation of Stress/Strain



Hyperbolic Representation



Programe Data
Revision No 3 (30/08/2010)