



TECHNICAL SPECIFICATIONS

FOR

CATHODIC PROTECTION & AC MITIGATION

INSTALLATIONS

ON

JOHANNESBURG WATER

BULK STEEL WATER PIPELINES

TABLE OF CONTENTS

1. General Preamble.....	5
1.1 Scope	5
1.2 Legal Requirements.....	5
1.3 Alternative Materials, Equipment & Work.....	5
1.4 Guarantee Period	6
1.5 Safety and Work Procedures.....	6
1.6 Handling and Storage	8
1.7 Cathodic Protection Design Requirements	8
1.8 Qualified Staff.....	8
1.9 Quality Assurance.....	8
1.9.1 Contractor Qualification	8
1.9.2 Quality Control	9
1.9.3 Quality Surveillance.....	9
1.10 Completion and Handover Documentation	10
2. Relevant Specifications	10
3. Glossary of Terms / Definitions.....	13
4. Cathodic Protection and AC Mitigation Materials	16
4.1 Impressed Current Anode Groundbed Materials	16
4.1.1 Mixed Metal Oxide Anodes	16
4.1.2 High silicon Iron Anodes	17
4.1.3 Anode and Spacer Canisters.....	18
4.1.4 Calcined Pitch Coke.....	18
4.1.5 Cable Jointing Kits	19
4.2 Transformer Rectifier Units	19
4.2.1 Manual Tap Change Transformer Rectifier Unit.....	19
4.2.2 Automatically Controlled Transformer Rectifier Unit.....	26
4.2.3 Switch Mode Cathodic Protection Rectifier Unit (SMCPR).....	35
4.3 Transformer Rectifier Unit Enclosures	44
4.3.1 Buried Type	45
4.3.2 Mega Bunker Type.....	45
4.3.3 Equipment Shelter Type.....	46

4.3.4	Transformer Rectifier Unit Enclosures Painting Requirements	46
4.3.5	Perimeter Security Measures for TRU Enclosures	46
4.4	Monitoring Facilities	49
4.4.1	Stationary Reference Electrodes	49
4.4.2	Coupons	50
4.4.3	IR Free Control Card	50
4.5	Monitoring and Bonding Facility Enclosures	50
4.5.1	Buried Type	50
4.5.2	Bunker Type	51
4.5.3	Big Head Test Post Type	51
4.5.4	Mega Big Head Test Post Type	52
4.5.5	UPVC/Concrete Test Post	52
4.5.6	Monitoring Structures Painting Requirements	52
4.6	Link Panels	52
4.7	Insulating Flanges	53
4.8	High Potential Magnesium Sacrificial Anodes	54
4.9	Sacrificial Anode Mounting Bracket	56
4.10	Gradient Control Mats	56
4.11	Gradient Control Wires	56
4.12	Solid State Decoupling Devices	57
4.13	Cathodic Protection Cables	59
4.14	Cable to Pipe Connections	59
4.15	Coating Repair	59
5.	Cathodic Protection and AC Mitigation Installations	60
5.1	Excavations	60
5.1.1	Cable and Anode Groundbed Trenches	60
5.1.2	Excavation of Pipelines	60
5.1.3	Excavation for Gradient Control Wire Installations	61
5.2	Concrete Encasement	61
5.2.1	Concrete Encasement of Cables	61
5.2.2	Concrete Encasement of Gradient Control Mats	61
5.3	Installation of Enclosures	61
5.3.1	Buried Type	61
5.3.2	Bunker and Mega Bunker Type	62

5.3.3	Equipment Shelter Type.....	62
5.3.4	Big Head Test Post and uPVC Test Post Type	62
5.4	Monitoring Facilities	62
5.4.1	Stationary Reference Electrodes.....	62
5.4.2	Coupons.....	63
5.4.3	IR Free Control Cards	63
5.5	Continuity and Cross Bonding Facilities.....	63
5.5.1	Continuity Bonds.....	63
5.6	Insulating Flange Materials	64
5.7	Sacrificial Anodes	64
5.7.1	Buried Installation	64
5.7.2	Valve Chamber Installation	64
5.8	Impressed Current Groundbeds	65
5.9	Gradient Control Mats.....	65
5.10	Gradient Control Wires	65
5.11	Solid State Decoupling Devices.....	66
5.12	Cables	66
5.13	Installation of Cable to Pipe Connections	66
5.14	Installation of Coating Repair Materials	66
Appendix 1 : Specification Drawings.....		68

1. General Preamble

1.1 Scope

This Specification defines the minimum and mandatory requirements governing the manufacturing, supply, and installation of both Cathodic Protection (CP) and AC mitigation (ACM) systems for Johannesburg Water's bulk water supply pipelines.

The "Client" shall refer to the asset owner's, in this case Johannesburg Water SOC Ltd, Corrosion Engineer or his designated representative.

The "CP Engineer" shall refer to the CP design engineer or his designated representative.

The "Contractor" shall refer to the supply and/or installation contractor.

Unless otherwise agreed by the purchaser's CP Engineer in writing, the materials and specifications used shall strictly follow the clauses of this specification.

The requirements of this specification may not necessarily be repeated in the bill of quantities or typical drawings issued. Thus, this specification must be strictly adhered to.

In the event of any detail that is not fully addressed in this specification and that is warranted to be carried out by the Contractor, the work shall be performed in accordance with the relevant applicable codes and best recognised engineering practices in the cathodic protection (CP/Corrosion) industry.

1.2 Legal Requirements

All works shall be conducted in compliance with the relevant sections of the OHS Act. the Contractor is responsible for ensuring that all personnel are equipped with appropriate PPE.

All materials, plant and equipment shall be the best of their respective kinds and spare parts, replacements and servicing facilities shall be readily available from local sources.

All work shall be carried out by qualified personnel and correctly supervised.

The Contractor shall be required to backfill and compact all excavations and ensure that all waste products and materials are removed from site and safely disposed of. All civil works are to be accepted/rejected by an approved competent civil professional.

Should any requirement of the project specification conflict with any requirements of the standardised or particular specifications listed in the list of specifications, the requirement of the project specification shall prevail.

1.3 Alternative Materials, Equipment & Work

If alternatives pertaining to materials, equipment and work method are submitted, the Contractor shall supply with their quotation/proposal all detailed specifications, designs, calculations, drawings, and a fully priced Schedule of Quantities as per the original quotation and/or any alterations and any further information that may be required by Johannesburg Water for the proper evaluation of the offer.

The attention of the Contractor is particularly drawn to the high standard of materials, workmanship, testing and performance applicable to the Contract as a whole.

Johannesburg Water reserves the right to carry out a factory inspection at their discretion.

Should any requirement or provision of the Project Specification conflict with any requirement of any standardised (SANS) specifications or any drawings, the order of precedence, unless otherwise specified, are:

- Project Specification
- Drawings
- SANS Specifications
- Schedule of Quantities

Note: Any discrepancies will be brought to the attention of the Engineer or designated representative in writing.

When all tests have been successfully completed to the satisfaction of Johannesburg Water, an Operational Acceptance Period shall commence and shall consist of a continuous period of operation of 12 months free from trouble.

During the operational acceptance period the Contractor shall carry out all necessary servicing and any adjustments required at their expense.

1.4 Guarantee Period

The Contractor is required to supply a written guarantee on the items supplied by them for a period of 2 years from date of site acceptance testing (SAT) under continuous working conditions after the successful completion of the abovementioned Operational Acceptance Period. The only exceptions shall be for damages arising from vandalism, mechanical damage, and external fire and/or flooding which are not caused by the Contractor.

Any faults as may be certified by Johannesburg Water due to poor materials, workmanship, or the Contractor's design (where applicable), shall be remedied and faulty goods replaced entirely at the Installation Contractor's cost.

The Contractor is responsible for the guarantee of all items under the terms of the tender and for the safe delivery and installation of the equipment and materials, as called for in the Schedule of Rates and Quantities, unless otherwise instructed in writing by Johannesburg Water.

1.5 Safety and Work Procedures

The Contractor shall ensure that a competent person is assigned to the works at all times in terms of OHS Act. The Contractor shall ensure that he complies with all statutory regulations, municipal by-laws, etc. concerning pollution and the health and safety of his personnel and members of the public who may be affected by his work. The Contractor shall provide for all necessary safety precautions and risk assessments and the loss control or safety officer shall prepare a safety plan for the area to be worked in. The Contractor shall advise the Engineer of all hazardous materials to be brought on site.

All electrical commissioning works and tie-ins to Eskom or the relevant power supplier shall be carried out by a qualified Electrician registered with the Electrical Contracting Board of South Africa.

All excavation and construction work shall be carried out strictly in accordance with the relevant Health and Safety regulations of local authorities or relevant departments within the Relevant Metropolitan Area.

Oily or solvent rags shall be kept segregated in closed containers and in minimum quantity. Any spillage of volatile material shall be wiped up immediately. Solvents and volatile materials shall be stored in designated areas.

The Contractor shall provide and erect such scaffolds and rigging as may be required. All scaffolds and rigging shall comply with the requirements of the OHS Act. Temporary welded support elements are not permitted except where written approval has been granted by the Engineer.

The Contractor shall ensure that the relevant electrical, civil, roads, rail or other departments are timeously informed of proposed project works. The necessary wayleave approval for each aspect of the work shall be kept on file for inspection during the project. On completion of the works, the Contractor shall include the wayleave forms with the documentation to be handed over to Johannesburg Water. Furthermore, the Contractor shall ensure that the relevant departments are approached to determine:

- Specific requirements according to the SAECC
- Specific department safety regulations.
- Specific construction restrictions and timing.
- Notification of work requirements.
- Procedures for work approval.
- Location of services that may be affected during construction.
- Public notification requirements to inform residents or business owners of potential disruptions.

The Contractor shall inform Johannesburg Water of the requirements and ensure that the relevant minutes of meetings with departments are kept of record for the duration of the works. The relevant project information and minutes of meetings with third parties shall be copied to Johannesburg Water at the end of the project. the Contractor shall prepare typical Hazard Identification and Risk Assessment forms for each of the major aspects of a construction project namely:

- Excavation, backfilling, and compaction.
- Lifting and moving of heavy equipment on site.
- Operation of machinery on site.

- Road traffic management.
- Working in trenches deeper than 1.5m.
- Managing pedestrian traffic nears construction works.
- Electrical testing, connections, and commissioning.
- Locking out and securing of sensitive areas during normal work hours and after hours.
- Entry into pipes of 800mm diameter or less.

1.6 Handling and Storage

The following precautions shall be taken for the site storage and handling of supplied items:

- All coated components shall be handled using soft slings and/or acceptable methods that will not cause damage.
- All components to be transported shall be loaded with support blocks, packaging and packing between pieces and tight lashing to avoid chafing.
- Off-loading at site shall be conducted using the same care and precautions for on-loading. Components shall not be tipped off the transportation.
- Coated corrosion protection items shall be stored under cover where possible.
- Items not stored under cover shall be stored in such a manner as to avoid retention of water and allow good air circulation.
- Items shall be stored on baulks of timber to raise the lowest level above the rain splash zone.
- Items shall be stacked using timber packing or other approved means to avoid item- to-item contact. Sufficient bearing area of packing shall be used to avoid damage to items.

1.7 Cathodic Protection Design Requirements

The Cathodic Protection system requirements i.e. design life, type, materials, supply, and installation method shall be as specified by the CP Engineer. The buried / immersed steel components should be designed to be accessible for the purposes of supplying, installing, applying, inspecting, and maintaining the CP system.

The guidelines to ensure accessibility and suitability for maintenance and upkeep of the complete CP system shall be drawn from SANS 15589 “Cathodic Protection of Pipeline Transportation systems; Part 1 On-Land pipelines”.

1.8 Qualified Staff

The Contractor shall ensure that there are at all times sufficient suitably qualified, experienced, and skilled staff to carry out and supervise all activities.

1.9 Quality Assurance

1.9.1 Contractor Qualification

All material, certification and records of the Contractor will be subject to examination by the CP Engineer. This shall include the checking and testing of the equipment. If any deviation to

the approved QCP or product quality is found, the Contractor may be instructed to perform additional testing and quality surveillance, at no additional cost to the Client. The CP Engineer may, at his discretion, require a Quality Audit of the Contractor's facility to ensure that he has the management, facilities, and skilled staff to carry out the work in accordance with the specification.

The Contractor shall accept full responsibility for the quality of his work and of materials used, irrespective of any quality surveillance that may be carried out by The CP Engineer.

1.9.2 Quality Control

The Contractor shall have the necessary equipment and qualified staff to carry out the quality control required to ensure compliance with the specification.

Quality control shall be carried out by a qualified inspector who is independent of the installation or construction activities. Quality control cannot be carried out by the site supervisor, or any member of staff involved in production and programming.

The Contractor shall keep at least the following records:

- Material Batch Records
- Site Data Sheets Records
- Records of Specific Tests as required by The CP Engineer

These records shall be kept in a format that meets the approval of The CP Engineer. The cost of quality control shall be included in the Contractor's tender price.

Before the commencement of the contract, the Contractor shall prepare a Quality Plan detailing each activity to be carried out during the execution of the works. Each activity shall be supported by a detailed Works Procedure for that activity. The Quality Plan will also detail the inspection requirements of each specific activity, listing whether it be a review, witness or hold point, and define the responsibilities of the various parties at each stage of the works.

The Contractor shall provide the necessary documentation to be used during these inspections. Such documentation shall be reviewed and approved by The CP Engineer beforehand.

1.9.3 Quality Surveillance

The CP Engineer or his representative shall perform independent quality assurance inspections.

For the purpose of carrying out quality surveillance, the CP Engineer shall be granted access to any part of the Contractor's premises relevant to the work being carried out, at any reasonable time. The Contractor shall provide, at his own cost, any equipment or labour necessary to gain access to the works that are in progress.

The CP Engineer or his representative may remove any reasonable samples of materials to carry out testing. Rejection of the samples will place a hold on the use of material of the same batch number and may lead to rejection of all that batch of material and the reworking of any components that have already been worked on with rejected material.

The CP Engineer may carry out reasonable destructive tests at his sole discretion to ascertain compliance with the specification.

A report shall be compiled by the CP Engineer for each visit. A copy of the report will be given to the Contractor on completion of each surveillance visit.

In the event that the materials pass the destructive testing, the Contractor will be entitled to bill the Client for destroyed materials. In the event that the materials fail the destructive testing, the Contractor will not be compensated for the destroyed materials.

1.10 Completion and Handover Documentation

The Contractor shall, on completion of a project provide full documentation for all installed equipment and materials including as-built drawings, data sheets, operations, and maintenance manuals etc. The documentation shall be provided in the form of 1 full colour hard copy and one electronic PDF on a USB C Memory Stick (flash drive).

2. Relevant Specifications

Below is a list of typical relevant specifications that may be used in the execution of a project. Where applicable, items specified in this document shall comply with the latest revision of the stated specifications and other specifications quoted or referred to within these documents:

NOTE: Where there is a contradiction, the project specification takes preference. The exact specifications to be used will be specified by the CP Engineer at the Pre-Job Conference also known as the “kick-off” meeting.

American Society for the Testing of Materials (ASTM)

ASTM B265-20a (2020) Standard specification for titanium and titanium alloy strip, sheet, and plate

ASTM B338-17 (2021) Titanium Alloy for Heat Exchangers

ASTM A518/A518M-99 (2022) Specification for corrosion resistant high silicon iron castings

ASTM G57-20 (2020) Method for field measurement of soil resistivity using the Wenner Four Electrode method

ASTM D293/D293M-18 (2018) Standard Test Method for the Sieve Analysis of Coke

British Standards Institution (BS) Specifications

BS EN IEC 60076 Power Transformers

BS 1016 Methods for analysis and testing of coal and coke

BS 1872 Specification of electroplated coatings on tin

BS 6001 Sampling Procedures for Inspection by Attributes

International Electrotechnical Commission (IEC) Publications

IEC 60038 2009 Standard voltages

IEC 60028 International Standard of Resistance for Copper.

IEC 60051 Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories.

IEC 60071 Insulation Co-ordination.

IEC 60076 Parts 1-5 Power Transformers.

IEC 60144 Degree of protection of enclosures for low voltage switchgear and control gear

IEC 60146 Semiconductor Converters.

IEC 60189 PVC Insulation and PVC Sheath.

IEC 60269 Low voltage fuses – Fuses mainly for Industrial applications.

IEC 60445 Identification of equipment terminals and of Terminations of certain designated Conductors, including general rules for Alphanumeric system.

IEC 60616 Terminal and tapping markings for power transformers.

National Association of Corrosion Engineers (NACE)

NACE SP0169 Control of External Corrosion on Underground or Submerged, Metallic Piping Systems

NACE SP0177 Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems

NACE SP0188 Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

NACE SP 0207 Performing close-interval DC pipe-to-electrolyte potential surveys on buried or submerged metallic pipelines

NACE SP0286 Electrical Isolation of Cathodically Protected Pipelines NACE SP0502 Pipeline External Corrosion Direct Assessment Methodology

NACE SP0572 Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds

NACE RP 0104 The Use of Coupons for Cathodic Protection Monitoring Applications

NACE TM 0102 Measurement of protective coating electrical conductance for underground pipeline

NACE TM 0109 Techniques for aboveground evaluation of the coating condition of underground metallic pipelines

NACE TM 0497 Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems

NACE Pub 10A190 Measurement Techniques Related to Criteria for Cathodic Protection of Underground or Submerged Steel Piping Systems

South African National Standards (SANS)

SANS 10142-1 2021 (Ed 3.01)	The wiring of premises Part 1: Low-voltage installations
SANS 1091 2012 (Ed 2.01)	National colour standards for paint
SANS 10129 2011 (Ed 1.02)	Plastic tape wrapping of steel pipelines.
SANS 10140 - Part 1 2008 (Ed 2.01), Part 2 2008 (Ed 2.03), Part 3 2017 (Ed 3.01):	Identification - Colour Marking.
SANS 10064 2011 (Ed 3.01)	Preparation of steel surfaces for coating.
SANS 121 2011 (Ed 2.0)	Hot dip galvanised coatings on fabricated iron and steel articles.
SANS 1700-7-1 2003 (Ed 2.0)	Fasteners (Hexagonal Head Bolts)
SANS 122-2020 (Ed 1.04)	Pressure-sensitive adhesive tapes for electrical purposes (Metric Units)
SANS 10199 2016 (Ed 2.02)	The design and installation of an earth electrode specifications
SANS 10313 2018 (Ed 3.03)	Protection against lightning – Physical damage to structures and life hazard
SANS 1063 2020 (Ed 4.01)	Earth rods, couplers, and connection
SANS 1411-1 2020 (Ed 2.02)	Materials of insulated electric cables and flexible cords Part 1: Conductors
SANS 1411-2 2014 (Ed 2.04)	Materials of insulated electric cables and flexible cords Part 2: Poly-Vinyl-Chloride (PVC)
SANS 1411-3 2014 (Ed 2.03)	Materials of insulated electric cables and flexible cords Part 3: Elastomers
SANS 1411-4 2014 (Ed 2.04)	Materials of insulated electric cables and flexible cords Part 4: Cross-linked Polyethylene (XLPE)
SANS 1411-5 2017 (Ed 3.03)	Materials of insulated electric cables and flexible cords Part 5: Halogen free, flame-retardant materials
SANS 1411-6 2008 (Ed 2.01)	Materials of insulated electric cables and flexible cords Part 6: Armour
SANS 1507-1 2020 (Ed 1.02)	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 1: General
SANS 1507-2 2018 (Ed 1.03)	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 2: Wiring cables
SANS 1507-3 2020 (Ed 1.04)	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 3: PVC distribution cables

SANS 1507-4	2022 (Ed 1.06)	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 4: XLPE distribution cables
SANS 1507-6	2021 (Ed 2.01)	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 6: Service cables
SANS 15589	2009 (Ed 1) Part 1	Petroleum and natural gas Industries – Cathodic Protection of pipeline transportation systems. Part 1: On-land pipelines.
SANS 50162	2010 (Ed 1.00)	Protection against corrosion by stray current from direct current systems.
SANS 53509	2009 (Ed 1.00)	Cathodic Protection measurement techniques
SABS 10142-1	2021 (Ed 3.1)	Wiring of Premises - LV Installations
SANS 10108	2023 (Ed 7.00)	The classification of hazardous locations and the selection of equipment for use in such locations
SANS 60529	2013 (Ed 1.2 and IEC Corr 1, 2)	Enclosures for electrical equipment classified by IP code
SANS 10086-1	2023 (Ed 4.02)	The installation, inspection and maintenance of equipment used in explosive atmospheres Part 1: Installations including surface installations on mines

The relevant SANS Standardised Specifications for Civil Construction shall apply.

It shall be the responsibility of the Contractor to obtain at his own expense, copies of the relevant editions of the documents referred to above. Subsequent amendments or revisions to these documents that have direct bearing on the project specification shall be clarified in writing with The CP Engineer before construction commences.

In addition to this, all elements of the Contract Documents shall be available for inspection on Site at all times.

3. Glossary of Terms / Definitions

AC:	Alternating Current
ACM:	Alternating Current Mitigation
Anode:	The electrode of an electrochemical cell at which oxidation occurs. Electrons flow away from the anode in the external circuit. Corrosion usually occurs and metal ions enter the solution at the anode.
Anode Groundbed:	One or more anodes installed below the Earth's surface for the purpose of providing a long-lasting, corrosion-resistant, positive connection to earth in a cathodic protection system, that enables the required current to pass into and through the electrolyte to the steel surface to be protected. A sacrificial anode groundbed sacrifices itself in favour of the steel structure being protected.

Bill of Quantities (BOQ):	The pricing instructions that are in the tender document that contains the quantities to be supplied or installed.
Bonding:	A method of connecting metal surfaces to each other by cable using exothermic or pin brazing techniques; often used to establish electrical continuity along pipelines coupled with mechanical joints.
Cathode:	An electrode of an electrochemical cell at which reduction (gain of electrons) is the principal reaction. Electrons flow toward the cathode in the external circuit.
Cathodic Protection:	The process to reduce or prevent corrosion of metal structures in contact with an electrolyte by the flow of direct current from the electrolyte into the structure surface.
Client:	The “Client” shall refer to the asset owner’s Corrosion CP Engineer or his designated representative.
Continuity Bonding:	A suitable electrical connection, usually metal, that provides electrical continuity between structures that can conduct electricity.
Contractor:	The supply and/or installation contractor.
CP Engineer:	The individual appointed by the Client who may be internal to the organisation or an outsourced Professional Service Provider.
Current Drainage Survey:	Survey aimed at determining the amount of DC current required to render a particular structure cathodic to accepted criteria.
DC:	Direct Current
Drain Point:	The point on the pipeline where the connection of the negative terminal of the cathodic protection voltage source is made to conduct (drain) the returning current from the pipeline to the foreign voltage source.
Electrolyte:	A conductive liquid or material such as soil or water in which an electric current can flow.
Earth Spike:	16 mm diameter, threaded type, 1.5 m long electroplated SANS 1063.
Earth Cable:	70 mm ² bare stranded copper
Exothermic Welding:	An exothermic welding process that makes use of copper oxide and aluminium powder to weld copper cables to a pipe or other steel structure.

Flange:	A mechanical joint comprising two flush steel faces, usually at pipe ends, used to join pipe lengths.
Forced Drainage Unit (FDU):	A unit comprising of a TRU and a bypass diode connected between pipe and rail.
Foreign Structures/Pipelines:	Metal structures or pipelines other than that under consideration in contact with the same electrolyte as the structure/pipeline and which are or may become under the influence of the structure/pipeline's cathodic protection system.
Impressed Current:	A DC electric current supplied by a device employing a power source that is external to the electrode system.
Insulating Flange:	An insulating flange typically comprises a gasket of phenol resin with insulating sleeves over high tensile bolts fitted with insulating washers. The purpose of the isolating flange is to stop current flow between a pipe and structural steel or earthing systems.
"IR Free" potential:	The pipe-to-soil potential measured immediately after the cathodic protection system is switched off and the applied electrical current stops flowing to the pipeline surface, but before polarisation of the pipeline has decreased.
Monitoring Enclosure:	An enclosure designed to house recording equipment for monitoring purposes.
Natural Drainage Unit (NDU):	An electrical device comprising a diode and surge protection units linked between pipe and rail to allow the flow of current back to the rail under certain conditions.
Natural Potential:	The pipe-to-soil potential measured shortly after installation of the pipe when the soil has been backfilled and compacted. No cathodic protection is applied, polarisation caused by cathodic protection is absent and no significant stray current is present.
OEM:	Original Equipment Manufacturer
"OFF" Potential:	The pipe-to-soil potential measured immediately after the cathodic protection system is switched off and the applied cathodic protection electrical current stops flowing to the pipeline surface but may still include stray current or foreign service interference in the measured value.
"ON" potential:	The pipe-to-soil potential measured while the cathodic protection system is continuously operating.
O&M:	Operations and Maintenance Manual (also OMM)

Pipe-to-Soil Potential:	The difference in electrochemical potential between a pipeline or foreign structure/pipeline and a specified reference electrode in contact with the electrolyte. Similar terms such as structure-to-soil potential, pipe to electrolyte potential are sometimes used as applicable in the particular context.
Polarisation:	The change of the pipe-to-soil potential caused by the flow of DC current between an electrolyte and a steel surface.
Reference Electrode:	An electrode with an open circuit potential that is constant under similar conditions of measurement, which is used for measuring the relative potential of other electrodes or metals under varying electrolyte environments.
Sacrificial Anode System:	Anodes manufactured from materials that are sacrificed preferentially when placed in a galvanic couple with another metal i.e. Magnesium coupled to steel in soil.
SRE:	Stationary Reference electrode
Stray Current:	Current that flows through paths other than an intended circuit i.e. current flow through the soil that originated from a DC traction railway line. The current may cause interaction with the cathodic protection system and often acts upon foreign structures and/or pipelines.
Transformer Rectifier Unit (TRU):	An electrical device designed with the purpose of stepping down either single or three phase power to a suitable voltage and then rectifying the power supply to provide a suitable DC output.
Viking-Johnson Type Coupling:	A coupling that uses a rubber seal on both sides of the coupling barrel, allowing flexibility of the joint, but also electrically insulating one length of pipe from another.

4. Cathodic Protection and AC Mitigation Materials

4.1 Impressed Current Anode Groundbed Materials

4.1.1 Mixed Metal Oxide Anodes

The anode construction shall be as follows:

Substrate	Ductile Pure Titanium
Length	1000mm
Diameter	25mm

Weight	910g
Anode Coating	Mixed Metal/Metal Oxide Plasma Sprayed or alternative ceramic.
Environment	Must be able to support oxygen and hydrogen evolution.
Tail cable	16mm ² PVC/PVC
Output current	8 Amps
Life expectancy	20 years at 8 Amps

The ceramic mixed metal/metal oxide coating must withstand the evolution of oxygen and chlorine and be compatible to ASTM B338, CP Titanium Grade 1 or 2.

Cable connection is to be at the centre of the anode, care has to be exercised so that no copper is exposed beneath the titanium tube which could result in anode string burnout.

The ends of the tubes have to be effectively sealed against ingress of moisture.

The cable to titanium tube connection resistance should be less than 500μΩ.

Anode tail cables shall be of sufficient length to connect directly with the ring main cable or distribution cabinet without buried splices.

Anodes are to be supplied with a certificate from the supplier confirming compliance with specification.

An anode from each supply batch may be randomly selected and tested by an accredited third-party laboratory as detailed below.

Test	Minimum requirement / test method
Test solution	10 % by volume Sulphuric Acid (H ₂ SO ₄)
Test temperature	Less than 50°C for duration of the test
Test current density	20 000A/m ² minimum
Test duration	Minimum of 36 days at the specified current density
Coating adhesion test	The coating adhesion shall comply in full to ASTM B571
Metallurgical/SEM analysis	Anodes will be sectioned and the MMO/PMO coating verified

4.1.2 High silicon Iron Anodes

The silicon iron anodes shall be centrifugally cast tubular anodes and manufactured in accordance with BS 5750 or ISO 9002.

The anodes shall typically have an external diameter of 71mm and an internal diameter of 45mm and be nominally 1 065mm long.

The anode shall possess a steel terminal, which shall be located centrally within the walls in order to ensure that the anode is consumed uniformly and to ensure that a balanced spread of current is achieved throughout its length.

A PVC/PVC (double insulated), colour red, stranded copper cable 16mm² shall be brazed to the steel terminal. The connection area shall be filled with a two pack, solvent free epoxy resin. The epoxy shall be cast in two separate installations for each end.

Great care must be taken to ensure that the brazing does not damage the PVC insulation. Care must also be taken to ensure that the epoxy covers a minimum of 30mm of the PVC/PVC insulation of the cable.

The anode connection and encapsulation shall be suitable for continuous use in wet conditions for 20 years.

The anode shall be free from internal porosity, blowholes, cracks, or inclusions.

The weight of the anode, without cable and epoxy shall be a minimum of 14kg and possess a minimum density of 7,0 g/ml.

The anode life shall be 40 Amp years minimum as determined for use without coke.

4.1.3 Anode and Spacer Canisters

Anode and spacer canisters are to be made up from galvanised spiral ventilation ducting with the ends being sealed with galvanised endcaps which are to be secured to the canister wall by means of pop rivets. Dimensions of canisters are given elsewhere.

Anode canisters are to be fitted with a PVC cable gland sized to match the anode tail size. The gland is to be installed at one end of the canister through the side wall.

Anodes are to be centralised in the anode canisters both radially and longitudinally and filled with calcined pitch coke.

Spacer canisters are to be filled with coke only.

During filling of canisters, the material is to be firmly tamped to ensure no cavities or air pockets form.

The assembled canisters are to be sufficiently robust to withstand transport, handling, and installation.

4.1.4 Calcined Pitch Coke

Calcined pitch coke to meet the following specification:

Table 1: Calcined Pitch Coke Specification

Element	Limits	Test Method
Fixed Carbon	99.50% min	ASTM D 4239-94
		100% (%Ash+%VCM)
Ash and Volatiles	0.25% max	ASTM D 4422-89
		BS 1016 Part 4
Sulphur	0.25% max	ASTM D 4239-94
Moisture	0.15% max	ASTM D 3173-78
Bulk Density	1200 Kg/m ³	ASTM D 527
Resistivity Vs Pressure	200 kPa	0.2180 ohm-cm
	400 kPa	0.1509 ohm-cm
	600 kPa	0.1139 ohm-cm
	800 kPa	0.0959 ohm-cm
	1000 kPa	0.0831 ohm-cm
Particle Size Distribution	95% between 0.15 and 1mm	ASTM D 293-69

4.1.5 Cable Jointing Kits

Cable jointing kits are to be of the low voltage type for 600/1000V insulated cables and are to comprise of the following:

- Two-part resin in transparent two chamber bag with integrated closed mixing and pouring (CMP) system. The resin expiry date is to be indicated on the resin packaging.
- Translucent mould body with snap fit closing system. Straight moulds are to be used for straight cable joints while branch moulds are to be used for anode tail to ring-main connections.
- Pre-cut foam sealing elements to provide reliable sealing to the mould body for all cable application diameters.
- Closure cap to prevent contamination.
- Suitably sized ferule or brass line tap for straight or branch cable connection respectively.

4.2 Transformer Rectifier Units

4.2.1 Manual Tap Change Transformer Rectifier Unit

4.2.1.1 General

The TRU is to comprise a step down, double wound Transformer requiring either a 240V or 380V supply, and a rectifier bridge to produce a DC output.

The TRU output voltage and output current are given in the bill of quantities. The Transformer shall be double wound and continuously rated in accordance with BS 171. The transformer shall have an earth screen between the primary and secondary to intercept voltage transients, and the insulation on the primary shall be able to withstand 16kV between phases and between phases and earth.

The transformer shall have suitable taps on the primary, or secondary windings, connecting to brass terminals for selection of the voltage. The latter shall have an insulating cover in order to prevent accidental contact with the live circuit.

The transformer must be capable of maintaining the output voltage constant within the designated current rating.

The Rectifier bridge shall consist of silicon diodes connected for full wave rectification and rated at twice full load current. Each diode shall be rated at 1600 PIV, and for continuous operation at 120°C. The diodes are to be mounted on aluminium heat sinks which will be cooled by convection cooling.

The diodes are to be screwed into the heat sink using a heat conducting paste which shall exclude moisture and care must be taken to apply the correct torque value when screwing in the diode.

The output voltage shall be adjusted manually by means of two rotary (tap) switches connected to taps on the primary or secondary of the Transformer. These shall be of the knife action type suitable for "on load" switching and sealed against the ingress of dust.

One tap switch shall be for coarse adjustment at 4 equal voltage intervals equal to 25% of the total voltage rating and one for fine switching at 4 equal voltage intervals equal to 25% of the coarse voltage intervals.

Protection against current surges shall be provided by means of a circuit breaker and fuses. The circuit breaker shall be of the thermal or magnetic type and located in the primary circuit before the power transformer. The circuit breaker must engage/disengage all phases of the AC supply and be capable of completely isolating the TRU except the 16A 220V switched socket.

A fuse is to be located in each of the phases between Transformer secondary and the bridge, and also on each of the positive and negative legs. The fuses must not only be capable of failing on a short circuit, but also when the output current exceeds the rated current by 40% and such that no part of the circuit is damaged.

A 0.5mH choke capable of continuously carrying the full load current is to be included in each of the positive and the negative legs immediately before the output terminals.

A shunt is to be included between the Rectifier bridge and the choke on the negative leg and connected to an ammeter for current measurement. The shunt is to be such that 1mV corresponds to 1 Amp.

The TRU is also to be fitted with surge protection devices and meters, the details of which are described below.

4.2.1.2 Meters and Monitors

The TRU shall include the following meters.

- DC voltmeter for measurement of output voltage
- DC voltmeter for measurement of pipe potential
- DC ammeter for measurement of output current
- DC hour meter
- AC Voltmeter for measurement of AC supply voltage between phases.
- kWhr meter

The pipe potential voltmeter is to be digital with a minimum input impedance of 10 megohms. The height of the LC display digits shall not be less than 12,5mm with an accuracy of 1,5% at maximum reading.

The pipe potential voltmeter shall be connected to the "pipe monitoring" terminal and the "reference electrode" terminal. The "pipe monitoring" terminal shall not be connected to the "pipe" terminal.

All other meters are to be analogue. The two DC voltmeters and DC ammeter are to be individually connected to a toggle switch, which must engage/disengage both leads to the meter.

The analogue meters shall be 96mm square with an accuracy of 1,5% at maximum reading.

All meters shall be discreet, sealed, and flush mounted (except for the kWhr meter).

The meters shall be labelled as follows:

Output Voltage	Reference Potential
Output Current	DC Hour Meter
kWhr Meter	AC Voltage

Two differently coloured captive terminal sockets (female banana jacks) must be located beneath each of the output voltmeter, output ammeter and reference voltmeter, to enable one to check that the meters are reading correctly. The value of the shunt must also be indicated below the ammeter e.g. 50mV 50A. The banana jack connected to the pipe must also be indicated for the output voltmeter, and the two banana jacks for the reference voltmeter must also be indicated.

The DC hour meter shall indicate the time the DC current has been flowing. Tenderers are to supply details of the DC hour meter circuit.

The DC output voltmeter shall have a "glass" type fuse in each lead.

Note: Female banana jacks must not be supplied for testing of the AC voltage.

4.2.1.3 Surge Protection

Indoor type lightning arrestors shall not be used.

Moving away from the rectifier bridge towards the output terminals, surge protection will be sequentially installed as follows:

Two off DehnGuard S 275 or equivalent, are to be connected in series between positive and negative legs. Between the two S 275 devices, a connection to the earth bar is to be made via a DehnGuard S 275. In addition to the above, a DehnGuard S 600 or equivalent, in parallel is to be connected between the positive and negative legs.

Followed by:

Between positive leg and earth, two parallel DehnGuard S 150 MOV in series with a Dehn Ex-FS (120kA) spark gap with Cu-W electrodes. Between the two DehnGuard S 150 and the spark gap described above, a Dehn Ex-FS (120kA) spark gap shall be connected to the negative leg. All spark gaps to have Copper Tungsten electrodes.

All the diodes are to have their own individual R - C snubber network.

4.2.1.4 Wiring and Busbars

Wherever possible flexible, multistrand cable is to be used.

Joints or splices in any wiring will not be permitted. Not more than two conductors shall be connected to any one terminal.

All conductors shall be numbered at both ends with reference to the Schematic Wiring Diagram supplied.

All conductors excluding busbars shall be routed in trunking or harnessed.

Busbars shall be aluminium or tinned copper. The latter shall be tinned after cutting, forming, and drilling. Tinning shall be in accordance with Grade Sn6C of BS 1872.

Busbar joints shall be bolted, and the mating surfaces coated with petroleum jelly or a similar water repellent paste prior to assembly.

Bolted joints shall be provided with spring washers. Fasteners on aluminium busbars shall be tinned or cadmium plated.

4.2.1.5 Colour Coding and Labelling

The following colour codings should be adhered to:

Positive electrical cables : Red

Negative electrical cables	:	Black	
Earth cables	:	Green/Yellow	
Electrical supply cables	:	(1st phase)	: Red or Brown
		(2nd phase)	: White
		(3rd phase)	: Blue
Cable for reference electrode	:	Red	
Electrical warning signs	:	Black on yellow background	
Monitoring cable	:	Black	

Power transformer secondary cables shall be grey, and they are to have an approximately 30mm heat shrink sleeve at either end, the colour of which is to be red (brown), white or blue as appropriate to the phase.

If busbars are used on the power transformer secondary, they are to be insulated by means of a yellow heat shrink sleeve.

All components and/or components assemblies shall be labelled.

Labels shall cross reference to the circuit diagram.

Labels shall be of the engraved type (multi-layered phenolic plastic) with black letters on a white background except the positive output terminal label which shall be in white letters on a red background. Alternatively aluminium silk screen labels may be used. Labels shall be in upper case letters with a height of 6mm for component labels and 10mm for output terminal labels.

Output terminals shall be labelled as follows:

+ GROUNDBED

- PIPE

PIPE MON

REF ELECT

EARTH

Labels shall be fixed by means of screws or pop rivets such that they shall not become dislodged during the life of the unit. Screws and rivets to be brass or aluminium. Cable tags to be plastic.

Cables shall be identified by means of permanently marked ferrules with black lettering on a white background. Ferrules shall be slip-on-type and matched to the size of the cable.

Ferrules shall be situated so as to read right way up on horizontal cables and from lug to insulation on vertical cables.

4.2.1.6 Cable Ends and Terminals

Cables shall be terminated at each end by means of lugs.

Control cable lugs shall be pre-insulated or insulated by means of heat shrink sleeves.

Power cable lugs shall be insulated by means of heat shrink sleeves or slip-on rubber shrouds colour coded as follows:

AC	:	Red, White, and Blue according to phase.
DC Positive (Groundbed)	:	Red
DC Negative (Pipe)	:	Black

All terminals shall be completely accessible after completion of all wiring.

Terminals on power connections shall be provided with lock nuts and washers.

Output terminals shall be fully insulated from the metal of the housing and shall comprise brass bolts, each provided with nuts, lock nuts, washers, and tinned copper cable lugs suitable for the specified cable size.

The negative terminal shall be M10 and the positive terminal M16.

Separate terminals size M6 shall be provided for the pipe monitoring cable, and reference electrode.

A 10mm diameter hole shall be drilled in the earth bar in order to facilitate connection via a lug to the earth cable.

4.2.1.7 Earthing

The surge diversion units shall all be connected to the common earth incorporating the primary AC supply earth, transformer screen and the transformer rectifier housing.

The common earth will consist of 30 x 3mm tinned copper or 40 x 5mm aluminium busbar.

On installation, the common earth shall be connected to a local earth by means of two 35mm² copper cables. The local earth is to be constructed so as to ensure a resistance of 10 Ohms or less is achieved.

All electrical circuits shall be floating with respect to earth.

4.2.1.8 Spares

The following spares are to be supplied with the TRU:

Fuses	:	three of each type and rating used
Diodes	:	two of each type and rating used
MOV	:	five of each type and rating for R-C network; 2 for all other MOV
Spark Gaps	:	one of each type and rating

The spares are to be mounted on the inside of the cabinet door.

4.2.1.9 Auxiliary AC Supply

The TRU shall be provided with a standard 220V single phase 16A 3-point plug for providing power to auxiliary devices. The auxiliary AC supply is to be protected by an earth leakage device. The three-point plug shall be connected to the input side of the main circuit breaker such that power is still available even if the main circuit breaker has tripped.

4.2.1.10 Inspection and Testing

The following tests shall be carried out at the Manufacturer's works. All equipment shall satisfactorily pass such tests and a test certificate made available to the CP Engineer. All testing shall be carried out at the Manufacturer's expense.

In the event that any of the tests detailed below, or the complete inspection, is waived, then this shall not release the Manufacturer from his obligation to supply completely satisfactory equipment or warranted performance as specified, and to supply "type test" results from essentially similar units.

4.2.1.10.1 Insulation Tests

The apparatus shall withstand a 1KV insulation test from the AC input to frame, DC output to frame, and primary to secondary sides of the main transformer.

The insulation test described earlier shall be repeated immediately on conclusion of the heat run test.

4.2.1.10.2 Efficiency Tests

Efficiency tests shall be carried out at 25%, 60% and 100% of maximum current at full rated voltage. A minimum efficiency of 65% is to be achieved.

4.2.1.10.3 Heat Run Tests

The units shall be run for at least 6 hours continuously at maximum current and voltage output with all the doors closed. The difference in temperature between the inside of the transformer rectifier and ambient shall be plotted against the time (in hours) and the test run until there is no increase in temperature difference (the curve levels off).

The maximum temperature difference increase shall be not more than 20°C.

A similar temperature time test shall be carried out on the main power rectifier bridge heat sink. The maximum temperature difference between heat sink and TRU internal shall not be more than 50°C.

The maximum temperature that may be obtained in the cabinet under any circumstances is 65°C.

4.2.1.10.4 Current Overload Tests

Tests shall be carried out to ensure that the circuit breaker or fuse operate under conditions where the current exceeds the rating of the TRU in a slowly rising mode. For this test the current is to be increased at 10A intervals every half hour starting from the TRU rating until one of the fuses or breaker operates. The results are to be entered into the performance test certificates.

The CP Engineer may also call for other tests to prove compliance with the specifications.

The tests shall be carried out in the presence of the CP Engineer. The successful Tenderer will issue a Test Certificate on completion of Tests which shall be signed by the CP Engineer.

4.2.1.10.5 Documentation

The Transformer Rectifier shall be supplied with the following:

- (1) Wiring / Circuit diagram with component list
- (2) Operations and Maintenance Manual

The above are to be mounted inside of the unit.

The Wiring Diagram with Component List are to be encapsulated in polyester fibreglass, mounted on an aluminium plate which shall be fixed by means of wing nuts to four studs welded to the TRU frame, thus rendering the drawing removable.

Six copies of the Operations and Maintenance Manuals are to be supplied to the CP Engineer for forwarding to the Client. The manual is to include a detailed fault finding / troubleshooting procedure.

4.2.1.11 Guarantee

The equipment shall carry an unconditional two-year guarantee except for damages arising from vandalism, mechanical damage, external fire, flooding, or ground subsidence caused by mining or earth tremors. The unit shall operate continuously on site for a period of 2 weeks after which the 2-year guarantee will commence.

4.2.2 Automatically Controlled Transformer Rectifier Unit

4.2.2.1 General

The TRU is to comprise a step down, double wound Transformer requiring a 220V or 380V supply, and a rectifier bridge to produce a DC output.

The TRU output voltage and current is given in the bill of quantities. The transformer shall be double wound and continuously rated in accordance with BS 171. Single wound (auto) transformers are not permitted except as a means of controlling the primary current of the main double wound transformer. The transformer shall have an earth screen between the primary and secondary to intercept voltage transients, and the insulation on the primary shall be able to withstand 16kV between phases, and between phases and earth.

The Transformer shall have suitable taps on the primary or secondary windings, connecting to brass terminals for coarse selection of the voltage. These shall have an insulating cover in order to prevent accidental contact with the live circuit. The voltage taps shall be equivalent to 40, 60, 80 and 100V DC for the 100V unit, 25, 50 and 76V DC for the 76V unit and 20, 35 and 50V DC for the 50V unit.

Protection against current surges shall be provided by means of a circuit breaker and fuses. The circuit breaker shall be of the thermal or magnetic type and located in the primary circuit before the power transformer. The circuit breaker must engage/disengage all phases of the AC supply and be capable of completely isolating the TRU except the 16A 220V switched socket (see latter).

A fuse is to be located in one of the legs (for single phase) and on each of the phases (for three phase) between Transformer secondary and the bridge, and also on each of the positive and negative legs. The fuses must not only be capable of failing on a short circuit, but also when the output current exceeds the rated current by 40% and such that no part of the circuit is damaged.

A 0.5mH choke capable of continuously carrying the full load current is to be included in the negative and positive legs immediately before the output terminals.

The Rectifier bridge shall consist of six silicon thyristors Semikron or equivalent, connected for full wave rectification, which shall be rated at twice full load current and 1600 PIV. The thyristors shall be rated for continuous operation of 120°C and are to be mounted on aluminium heat sinks which may be cooled by convection cooling or forced cooling. If forced cooling is employed the heat sink may be mounted anywhere in the cabinet, but the heatsinks must have a thermal switch which will stop the operation of the unit if the temperature rise is excessive, and which will automatically reset once the temperatures has dropped. The heat sinks are to be mounted on the lower half of the cabinet if the convection cooling method is employed.

Care must be taken not to exceed the manufacturer's torque value when screwing in the thyristor. The thyristors are to be screwed into the heat sink using a heat conducting paste which shall exclude moisture.

The output voltage shall be infinitely variable by means of an electronic control circuit acting on the thyristors. This circuit shall also have current limiting facilities. Both the "constant current" and "current limit" facilities are to act on the total output current and not on the Rectifier part of the circuit or the bypass circuit.

Units which use the rails as the anode have a bypass diode; the latter is simply a power diode capable of shunting excessive currents (several hundred amps) from pipe to rail without going through the Transformer or Rectifier circuit. The bypass diode is located close to the DC output terminals.

A DC current transformer shall be included between the rectifier bridge and the choke and connected to an ammeter for measurement of Rectifier Current.

A current measuring shunt is to be located on the negative leg with the measuring cables terminating at two female banana terminals under the DC ammeter. The shunt is to be such that 1mV corresponds to 1A.

In parallel with the negative cable, a monitor cable shall be connected to the pipeline and connected to the monitor terminal. This cable shall not carry "current" and is to be used only for measurement of pipe-to-soil potential.

4.2.2.2 Control Circuit

The control circuit shall control the firing of the thyristors and perform the following functions:

- (1) Maintain output current constant at any preset value
- (2) Maintain pipe potential constant at any preset value
- (3) Have current limit facility at any value of output current

All the above functions shall be carried out by one Control Card. All the connections to the Control Card are to be by means of a plug-in ribbon cables.

The TRU must have a ready mounted spare Control Card such that in the case of failure of the one card the ribbon cable may be disconnected and connected to the spare card.

The current limit facility shall be adjustable from 0 - 100% of current output via a suitable wire wound pot and the knob must be set (calibrated) against a graduated scale marked 0 - 10, with 10 the maximum output of the TRU.

When operating in the constant potential mode, in the event of failure of the monitoring or reference cables, or of the reference electrode itself, the TRU must operate at the preset current limit.

Selection of operation (constant current/constant potential) is to be by means of a suitably marked change over switch.

The wiring must be such that the electronic control circuit makes contact with the monitor and reference cables only when the change-over switch is in the constant potential mode.

In the constant current mode, the feed-back signal is to come from a DC CT and not from a shunt.

4.2.2.3 Meters and Monitors

The TRU shall include the following meters:

- DC voltmeter for measurement of output voltage
- DC voltmeter for measurement of pipe potential
- DC ammeter for measurement of output current
- DC ammeter for measurement of by-pass current (for FDU's)
- DC hour meter
- AC Voltmeter for measurement of AC supply voltage between phases.
- kWhr meter

The pipe potential voltmeter is to be digital with LCD display and with minimum input impedance of 10 megohms. The height of the LCD display digits shall not be less than 12,5mm with an accuracy of 1,5% at maximum reading.

The pipe potential voltmeter shall be connected to the "pipe monitoring" terminal and the "reference electrode" terminal. The "pipe monitoring" terminal shall not be connected to the "pipe" terminal.

All other meters are to be analogue. The two DC voltmeters and DC ammeter are to be individually connected to a toggle switch, which must engage/disengage both leads to the meter.

The analogue meters shall be 96mm square with an accuracy of 1,5% at maximum reading.

All meters shall be discreet, sealed, and flush mounted (except for the kWhr meter).

The meters shall be labelled as follows:

Output Voltage	Reference Potential
Output Current	By-Pass Current
DC Hour Meter	AC Voltage
kWhr Meter	

Two differently coloured captive terminal sockets (female banana jacks) must be located beneath each of the output voltmeter, output ammeter and reference voltmeter, to enable one to check that the meters are reading correctly. The value of the shunt must also be indicated below the ammeter e.g. 50mV 50A.

The banana jack connected to the pipe must also be indicated for the output voltmeter and the two banana jacks connected to the reference voltmeter must also be indicated.

The DC hour meter shall indicate the time the DC current has been flowing. Tenderers are to supply details of the DC hour meter circuit.

The DC output voltmeter shall have a "glass" type fuse in each lead.

Note: Female banana jacks must not be supplied for testing of the AC voltage.

4.2.2.4 Surge Protection

4.2.2.4.1 Load Surge Protection

Indoor type lightning arrestors shall not be used.

Moving away from the rectifier bridge towards the output terminals, surge protection will be sequentially installed as follows:

Two off DehnGuard S 275 or equivalent, are to be connected in series between positive and negative legs. Between the two S 275 devices, a connection to the earth bar is to be made via a DehnGuard S 275. In addition to the above, a DehnGuard S 600 or equivalent, in parallel is to be connected between the positive and negative legs.

Followed by:

A 0,5mH Choke in the positive leg

A 0,5mH Choke in the negative leg

Followed by:

Between positive leg and earth, two parallel DehnGuard S 150 MOV in series with a Dehn Ex-FS (120kA) spark gap with Cu-W electrodes. Between the two DehnGuard S 150 and the spark gap described above, a Dehn Ex-FS (120kA) spark gap shall be connected to the negative leg. All spark gaps to have Copper Tungsten electrodes.

In place of the spark gaps, and Dehn MOVs, an Electrolytic varistor may be installed.

All thyristors are to have their own individual R - C rubber network.

4.2.2.4.2 Electronic Circuit Surge Protection

The electronic circuit must be protected from both the AC and DC sides.

The DC feed into the control module shall have the following surge protection:

From the pipe monitor cable terminal a 100-ohm 100 watt 300 μ H resistive choke shall be installed in line with the DVM and Control Module, followed by an MOV to earth, type Semikron SKVA20B130 or equivalent.

After the above, between the monitor and the reference circuits, a Dehn Blitzductor (92744) clamping voltage or equivalent, is to be installed.

An earth screen is to be located between the primary and secondary of the 380/18V or 220/18V transformer supplying power to the electronic circuitry.

Immediately on the output of the above transformer (18V) a Dehn surge arrester or equivalent, Dehn Blitzductor (92744), is to be located between each phase and star point.

An earth screen is to be located between the primary and secondary of the transformer supplying power to the electronic circuitry.

4.2.2.5 Wiring and Busbars

Wherever possible flexible, multistrand cable is to be used.

Joints or splices in any wiring will not be permitted. Not more than two conductors shall be connected to any one terminal.

All conductors shall be numbered at both ends with reference to the Schematic Wiring Diagram supplied.

All conductors excluding busbars shall be routed in trunking or harnessed.

Busbars shall be aluminium or tinned copper. The latter shall be tinned after cutting, forming, and drilling. Tinning shall be in accordance with Grade Sn6C of BS 1872.

Busbar joints shall be bolted, and the mating surfaces should be coated with petroleum jelly, or a similar water repellant paste prior to assembly.

Bolted joints shall be provided with spring washers. Fasteners on aluminium busbars shall be tinned or cadmium plated.

4.2.2.6 Colour Coding and Labelling

The following colour codings should be adhered to:

Positive electrical cables	:	Red
Negative electrical cables	:	Black
Earth cables	:	Green/Yellow
Electrical supply cables	:	(1st phase) : Red or Brown
		(2nd phase) : White
		(3rd phase) : Blue
Cable for reference electrode	:	Red
Electrical warning signs	:	Black on yellow background
Monitoring cable	:	Black

Power transformer secondary cables shall be grey, and they are to have an approximately 30mm heat shrink sleeve at either end, the colour of which is to be red (brown), white or blue as appropriate to the phase.

If busbars are used on the power transformer secondary, they are to be insulated by means of a yellow heat shrink sleeve.

All components and/or components assemblies shall be labelled.

Labels shall cross reference to the circuit diagram.

Labels shall be of the engraved type (multi-layered phenolic plastic) with black letters on a white background except the positive output terminal label which shall be in white letters on a red background. Alternatively aluminium silk screen labels may be used.

Labels shall be in upper case letters with a height of 6mm for component labels and 10mm for output terminal labels.

Output terminals shall be labelled as follows:

- + GROUND BED
- PIPE
- PIPE MON
- REF ELECT
- EARTH

Labels shall be fixed by means of screws or pop rivets such that they shall not become dislodged during the life of the unit. Screws and rivets to be brass or aluminium. Cable tags to be plastic.

Cables shall be identified by means of permanently marked ferrules with black lettering on a white background. Ferrules shall be slip-on-type and matched to the size of the cable.

Ferrules shall be situated so as to read right way up on horizontal cables and from lug to insulation on vertical cables.

4.2.2.7 Cable Ends and Terminals

Cables shall be terminated at each end by means of lugs.

Control cable lugs shall be pre-insulated or insulated by means of heat shrink sleeves.

Power cable lugs shall be insulated by means of heat shrink sleeves or slip-on rubber shrouds colour coded as follows:

AC	:	Red, White, and Blue according to phase.
DC Positive (Groundbed/Rail)	:	Red
DC Negative (Pipe)	:	Black

All terminals shall suitably labelled and be completely accessible after completion of all wiring.

Terminals on power connections shall be provided with lock nuts and or spring washers.

Output terminals shall be fully insulated from the metal of the housing and shall comprise brass bolts, each provided with nuts, lock nuts, washers, and tinned copper cable lugs suitable for the specified cable size.

The negative terminal shall be M10 and the positive terminal M16.

Separate terminals size M6 shall be provided for the pipe monitoring cable, and reference electrode cable.

A 10mm diameter hole shall be drilled in the earth bar in order to facilitate connection via a lug to the earth cable.

4.2.2.8 Earthing

The surge diversion units shall all be connected to the common earth incorporating the primary AC supply earth, transformer screen and the transformer rectifier housing.

The common earth will consist of 30 x 3mm tinned copper or 40 x 5mm aluminium busbar.

On installation, the common earth shall be connected to a local earth by means of two 35mm² copper cables.

All electrical circuits shall be floating with respect to earth.

4.2.2.9 Spares

The following spares are to be supplied with the TRU:

Fuses	:	three of each type and rating used
Diodes	:	two of each type and rating used
MOV	:	five of each type and rating for R-C network; 2 for all other MOV
Spark Gaps	:	one of each type and rating
Control Card	:	one off

4.2.2.10 Safety Devices

The TRU must contain certain devices which will protect the unit from damage during gross overheating conditions. This may arise during particularly hot weather conditions and/or when the TRU operates at a current output exceeding the rated output but below that of an outright short. It should also be pointed out that excessive current may also cause damage to the cables external to the TRU.

The TRU shall therefore contain the following safety devices:

1) Circuit Breaker:

This shall be matched as close as possible to the rating of the TRU output current and shall not merely be used as an isolation switch.

2) Thermal Switch:

A Thermal cut out switch shall be mounted on the power thyristor heat sink assembly and shall automatically engage/disengage when the temperature reaches 85°C.

3) DC Fuses:

The DC fuses shall operate before or when the output current reaches a value of 40% greater than the TRU rated value. This value shall also be such that no damage to any of the components or wiring occurs.

4.2.2.11 Bypass Circuit

Where the TRU is to be used with the railway as the anode, it is to be supplied with a bypass circuit which shall consist of a 3000 PIV 800A diode mounted on an appropriate heat sink in series with a 200A fuse and a 200mV 200A shunt. These components are to be mounted across the positive and negative legs between the electrolytic varistor and the chokes. The need for a bypass diode will be indicated, in the Bill of Quantities.

4.2.2.12 Auxiliary AC Supply

The TRU shall be provided with a standard 220V single phase 16A 3-point plug for providing power to auxiliary devices. The auxiliary AC supply is to be protected by an earth leakage

device. The three-point plug shall be connected to the input side of the main circuit breaker such that power is still available even if the main circuit breaker has tripped.

4.2.2.13 Inspection and Testing

The following tests shall be carried out at the Manufacturer's works (unless an alternative place is specified and approved by the CP Engineer). All equipment shall satisfactorily pass such tests and a test certificate made available to the Purchaser. All testing shall be carried out at the Manufacturer's expense.

In the event that any of the tests detailed below, or the complete inspection, is waived, then this shall not release the Manufacturer from his obligation to supply completely satisfactory equipment or warranted performance as specified, and to supply "type test" results from essentially similar units.

4.2.2.13.1 Insulation Tests

The apparatus shall withstand a 16kV insulation test from the AC input to frame, DC output to frame, and primary to secondary sides of the main transformer.

The insulation test described earlier shall be repeated immediately on conclusion of the heat run test.

4.2.2.13.2 Efficiency Tests

Efficiency tests shall be carried out at 25%, 60% and 100% of maximum current at full rated voltage. A minimum efficiency of 65% is to be achieved.

4.2.2.13.3 Heat Run Tests

The units shall be run for at least 6 hours continuously at maximum current and voltage output with all the doors closed. The difference in temperature between the inside of the transformer rectifier and ambient shall be plotted against the time (in hours) and the test run until there is no increase in temperature difference (the curve levels off).

The maximum temperature difference increase shall be not more than 20°C.

A similar temperature time test shall be carried out on the main power rectifier bridge heat sink. The maximum temperature difference between heat sink and TRU internal shall not be more than 50°C.

The maximum temperature that may be obtained in the cabinet under any circumstances is 65°C.

4.2.2.13.4 Constant Current / Potential Tests

Constant current and constant potential tests shall be carried out on thyristor control units at various voltage and current levels as decided by the CP Engineer. For the constant potential test the supplier shall have available a 200-litre drum filled with appropriate solution, together with relevant anode, cathode, and reference electrode.

The control parameters are to remain within 5% of any preset value above 5% of the rectifier output voltage.

4.2.2.13.5 Current / Overload Tests

Tests shall also be carried out to ensure that the circuit breaker or fuse operate under conditions where the current exceeds the rating of the TRU in a slowly rising mode.

The rectifier shall be run at increasing steps of 10A for 30minutes, starting from the maximum current rating of the unit, until one of the fuses or breakers operates. The results of the tests are to be entered on the performance test certificate.

The CP Engineer may also call for other tests to prove compliance and the specifications.

The tests shall be carried out in the presence of the CP Engineer. The Manufacturer will issue a Test Certificate on completion of Tests which shall be signed by the CP Engineer.

4.2.2.15 Documentation

The Transformer Rectifier shall be supplied with the following:

- (1) Wiring / Circuit diagram with component list
- (2) Operations and Maintenance Manual

The above are to be mounted on the inside of the unit.

The Wiring Diagram with Component List are to be encapsulated in polyester fibreglass, mounted on an aluminium plate which shall be fixed by means of wing nuts to four studs welded to TRU frame, thus rendering the drawing removable.

Six copies of the Operations and Maintenance Manuals are to be supplied to the CP Engineer for forwarding to the Client.

The manual is to include a detailed fault finding and troubleshooting procedure.

4.2.2.16 Guarantee

The equipment shall carry an unconditional two-year guarantee except for damages arising from vandalism, mechanical damage, external fire, flooding, or ground subsidence caused by mining or earth tremors. The unit shall operate continuously on site for a period of 2 weeks after which the 2-year guarantee will commence.

4.2.3 Switch Mode Cathodic Protection Rectifier Unit (SMCPR)

4.2.3.1 General

The SMCPR is to comprise an input rectifier and filter, a high frequency inverter, a high frequency output transformer, output rectifier and a smoothing circuit. The smoothing circuit shall ensure ripple is less than 2% of output voltage. The output of the unit is to be controlled by means of a high speed PID control circuit such that the response time of the unit is less than 100mS.

The SMCPR is to have an output capacity as given in the bill of quantities with the ratio of current to voltage to be configurable as required.

The unit shall have a power factor correction of greater than 0.99 and an energy efficiency of 70% to 95% dependent on output settings.

Protection against current surges from the AC supply shall be provided by means of a circuit breaker and fuses. The circuit breaker shall be of the thermal or magnetic type and located before the input rectifier. The circuit breaker must be capable of completely isolating the power supply except the 16A 220V switched socket (see later).

The power semiconductors are to be mounted on aluminium heat sinks cooled by convection cooling. No forced cooling is permitted.

The output voltage shall be infinitely variable within the capacity limits of the unit by means of a control circuit acting on the inverter circuit. This circuit shall also have current limiting facilities.

Output DC current, output DC voltage, incoming AC voltage, reference potential, current set point and potential set point are to be displayed on the digital display.

Banana plug terminals are to be located under the digital display to allow for manual measurement of output DC current, output DC voltage and reference potential.

In parallel with the negative cable, a monitor cable shall be connected to the pipeline and connected to the monitor terminal. This cable shall not carry "current" and is to be used only for measurement of potential.

The SM CPR shall be of such a design and size that it may be installed inside a precast concrete bunker type or an underground type enclosure.

4.2.3.2 Control Circuit

The control circuit shall perform the following functions:

- (1) Maintain output current constant at any preset value within the capacity limits of the unit.
- (2) Maintain pipe potential constant at any preset value within the capacity limits of the unit.

When operating in the constant potential mode, in the event of failure of the monitoring or reference cables, or of the reference electrode itself, the SM CPR must operate at the preset current limit.

The control circuit shall have the following additional built-in features:

- Integrated interrupter – GPS synchronised
- Communication interface – Modbus RS232, GSM
- Data Logging – Output current, output voltage, reference potential, heat sink temperature, all recorded events must be time stamped.

- Alarm monitoring – AC and DC surge protection failure, AC circuit breaker trip, DC output breaker trip, door open switch. All alarms are to be displayed on the digital display.
- Interface with Johannesburg Water Scada system – the controller shall be capable of interfacing directly with the Scada system

4.2.3.3 Surge Protection

4.2.3.3.1 Load Surge Protection

Indoor type lightning arrestors shall not be used.

Moving away from the smoothing circuit towards the output terminals, surge protection will be sequentially installed as follows:

Two off DehnGuard S 275 or equivalent, are to be connected in series between positive and negative legs. Between the two S 275 devices, a connection to the earth bar is to be made via a DehnGuard S 275. In addition to the above, a DehnGuard S 600 or equivalent, in parallel is to be connected between the positive and negative legs.

Followed by:

A 0.5mH Choke in the positive leg

A 0.5mH Choke in the negative leg

Followed by:

Between positive leg and earth, two parallel DehnGuard S 150 MOV in series with a Dehn Ex-FS (120kA) spark gap with Cu-W electrodes. Between the two DehnGuard S 150 and the spark gap described above, a Dehn Ex-FS (120kA) spark gap shall be connected to the negative leg. All spark gaps to have Copper Tungsten electrodes.

4.2.3.3.2 Electronic Circuit Surge Protection

The electronic circuit must be protected from both the AC and DC sides.

The DC feed into the control module shall have the following surge protection:

From the pipe monitor cable terminal a 100-ohm 100 watt 300 μ H resistive choke shall be installed in line with the Control Module, followed by an MOV to earth, type Semikron SKVA20B130 or equivalent.

After the above, between the monitor and the reference circuits, a Dehn Blitzductor (92744) clamping voltage or equivalent, is to be installed.

An earth screen is to be located between the primary and secondary of the step-down transformer supplying power to the electronic circuitry.

Immediately on the output of the above transformer a Dehn surge arrestor or equivalent, Dehn Blitzductor (92744), is to be located between live and neutral.

4.2.3.4 Wiring and Busbars

Wherever possible flexible, multistrand cable is to be used.

Joints or splices in any wiring will not be permitted. Not more than two conductors shall be connected to any one terminal.

All conductors shall be numbered at both ends with reference to the Schematic Wiring Diagram supplied.

All conductors excluding busbars shall be routed in trunking or harnessed.

Busbars shall be aluminium or tinned copper. The latter shall be tinned after cutting, forming, and drilling. Tinning shall be in accordance with Grade Sn6C of BS 1872.

Busbar joints shall be bolted, and the mating surfaces should be coated with petroleum jelly, or a similar water repellant paste prior to assembly.

Bolted joints shall be provided with spring washers. Fasteners on aluminium busbars shall be tinned or cadmium plated.

4.2.3.5 Colour Coding and Labelling

The following colour codings should be adhered to:

Positive electrical cables	:	Red
Negative electrical cables	:	Black
Earth cables	:	Green/Yellow
Electrical supply cables		
(1st phase)	:	Red or brown
(2nd phase)	:	White
(3rd phase)	:	Blue
Cable for reference electrode	:	Red
Electrical warning signs	:	Black on yellow background
Monitoring cable	:	Black

All components and/or components assemblies shall be labelled.

Labels shall cross reference to the circuit diagram.

Labels shall be of the engraved "sandwich" type (multi-layered phenolic plastic) with black letters on a white background except the positive output terminal label which shall be in white letters on a red background. Alternatively aluminium silk screen labels may be used.

Labels shall be in upper case letters with a height of 6mm for component labels and 10mm for output terminal labels.

Output terminals shall be labelled as follows:

+ GROUNDBED

- PIPE

PIPE MON

REF ELECT

EARTH

Labels shall be fixed by means of screws or pop rivets such that they shall not become dislodged during the life of the unit. Screws and rivets to be brass or aluminium. Cable tags to be plastic.

Cables shall be identified by means of permanently marked ferrules with black lettering on a white background. Ferrules shall be slip-on-type and matched to the size of the cable.

Ferrules shall be situated so as to read right way up on horizontal cables and from lug to insulation on vertical cables.

4.2.3.6 Cable Ends and Terminals

Cables shall be terminated at each end by means of lugs.

Control cable lugs shall be pre-insulated or insulated by means of heat shrink sleeves.

Power cable lugs shall be insulated by means of heat shrink sleeves or slip-on rubber shrouds colour coded as follows:

AC : Red, White, and Blue according to phase.

DC Positive : Red

DC Negative (Pipe) : Black

All terminals shall suitably labelled and be completely accessible after completion of all wiring.

Terminals on power connections shall be provided with lock nuts and or spring washers.

Output terminals shall be fully insulated from the metal of the housing and shall comprise brass bolts, each provided with nuts, lock nuts, washers, and tinned copper cable lugs suitable for the specified cable size.

The negative terminal shall be M10 and the positive terminal M16.

Separate terminals size M6 shall be provided for the pipe monitoring cable, and reference electrode cable.

A 10mm diameter hole shall be drilled in the earth bar in order to facilitate connection via a lug to the earth cable.

4.2.3.7 Earthing

The surge diversion units shall all be connected to the common earth incorporating the primary AC supply earth, transformer screens and the SM CPR housing.

The common earth will consist of 30 x 3mm tinned copper or 40 x 5mm aluminium busbar.

On installation, the common earth shall be connected to a local earth by means of two 35mm² copper cables.

All electrical circuits shall be floating with respect to earth.

4.2.3.8 Spares

The following spares are to be supplied with the SM CPR:

Fuses	:	three of each type and rating used
Power Semiconductors	:	two of each type and rating used
MOV	:	2 of each type of MOV
Spark Gaps	:	one of each type and rating

4.2.3.9 Safety Devices

The SM CPR must contain certain devices which will protect the unit from damage during gross overheating conditions. This may arise during particularly hot weather conditions and/or when the SM CPR operates at a current output exceeding the rated output but below that of an outright short. It should also be pointed out that excessive current may also cause damage to the cables external to the SM CPR.

The SM CPR shall therefore contain the following safety devices:

1) Circuit Breaker:

This shall be matched as close as possible to the rating of the SM CPR output current and shall not merely be used as an isolation switch.

2) Thermal Switch:

A Thermal cut out switch shall be mounted on the power thyristor heat sink assembly and shall automatically engage/disengage when the temperature reaches 85`C.

3) DC Fuses:

The DC fuses shall operate before or when the output current reaches a value of 40% greater than the SM CPR rated value. This value shall also be such that no damage to any of the components or wiring occurs.

4.2.3.10 Auxiliary AC Supply

The SM CPR shall be provided with a standard 220V single phase 16A 3-point plug for providing power to auxiliary devices. The auxiliary AC supply is to be protected by an earth

leakage device. The three-point plug shall be connected to the input side of the main circuit breaker such that power is still available even if the main circuit breaker has tripped.

4.2.3.11 Inspection and Testing

The following tests shall be carried out at the Manufacturer's works (unless an alternative place is specified and approved by the CP Engineer). All equipment shall satisfactorily pass such tests and a test certificate made available to the Purchaser. All testing shall be carried out at the Manufacturer's expense.

In the event that any of the tests detailed below, or the complete inspection, is waived, then this shall not release the Manufacturer from his obligation to supply completely satisfactory equipment or warranted performance as specified, and to supply "type test" results from essentially similar units.

4.2.3.11.1 Insulation Tests

The apparatus shall withstand a 16kV insulation test from the AC input to frame, DC output to frame.

The insulation test described earlier shall be repeated immediately on conclusion of the heat run test.

4.2.3.11.2 Efficiency Tests

Efficiency tests shall be carried out at 25%, 60% and 100% of maximum current at full rated voltage. A minimum efficiency of 70% is to be achieved.

4.2.3.11.3 Heat Run Tests

The unit shall be run for at least 6 hours continuously at maximum current and voltage output with the door of the enclosure closed. The difference in temperature between the inside of the enclosure and ambient shall be plotted against the time (in hours) and the test run until there is no increase in temperature difference (the curve levels off).

The maximum temperature difference increase shall be not more than 20°C.

A similar temperature time test shall be carried out on the heat sink. The maximum temperature difference between heat sink and SMCP internal shall not be more than 50°C.

The maximum temperature that may be obtained in the cabinet under any circumstances is 55°C.

4.2.3.11.4 Constant Current / Potential Tests

Constant current and constant potential tests shall be carried out at various voltage and current levels as decided by the CP Engineer. For the constant potential test the supplier shall have available a 200-litre drum filled with appropriate solution, together with relevant anode, cathode, and reference electrode.

The control parameters are to remain within 5% of any preset value above 5% of the rectifier output voltage.

4.2.3.11.5 Current / Overload Tests

Tests shall also be carried out to ensure that the circuit breaker or fuse operate under conditions where the current exceeds the rating of the SMCPD in a slowly rising mode.

The rectifier shall be run at increasing steps of 10A for 30minutes, starting from the maximum current rating of the unit, until one of the fuses or breakers operates. The results of the tests are to be entered on the performance test certificate.

The CP Engineer may also call for other tests to prove compliance to the specifications.

The tests shall be carried out in the presence of the CP Engineer. The Manufacturer will issue a Test Certificate on completion of Tests which shall be signed by the CP Engineer.

4.2.3.12 Documentation

The Rectifier shall be supplied with the following:

- (1) Wiring / Circuit diagram with component list
- (2) Operations and Maintenance Manual

The above are to be mounted on the inside of the unit.

The Wiring Diagram with Component List are to be encapsulated in polyester fibreglass, mounted on an aluminium plate which shall be fixed by means of wing nuts to four studs welded to the door, thus rendering the drawing removable.

Six copies of the Operations and Maintenance Manuals are to be supplied to the CP Engineer for forwarding to the Client.

The manual is to include a detailed fault finding and troubleshooting procedure.

4.2.2.13 Guarantee

The equipment shall carry an unconditional two-year guarantee except for damages arising from vandalism, mechanical damage, external fire, flooding, or ground subsidence caused by mining or earth tremors. The unit shall operate continuously on site for a period of 2 weeks after which the 2-year guarantee will commence.

4.2.4 Natural Drainage Unit

4.2.4.1 General

Stray current corrosion is generally caused by traction DC currents, which leave the pipe to return to the rail via the ground. If the current returns via a metallic conductor, rather than through the ground, corrosion is prevented, and protection is achieved. The above situation occurs when the rail is at a negative potential and the pipe at a positive potential with respect

to the rail. The function of the NDU is to drain off the current back to the rail in a manner such as not to cause corrosion. The rail potential normally fluctuates, however, and when it goes positive the pipe will also be at a positive potential (if the two are connected via a normal bond) and hence undergo accelerated corrosion.

An NDU is essentially a unidirectional current device with associated surge protection, fuses, etc. It is critically important that the diode does not fail, but should it fail, the fuse shall operate promptly. Surge protection is therefore of the utmost importance and the fuse must be matched according to the maximum current which is likely to be drained.

4.2.4.2 Electrical Layout

The Natural Drainage Unit shall consist of a surge diode, together with fuses, chokes, ammeter, disconnecting link and surge protection devices.

From the pipe terminal, a busbar shall connect to the diode anode via a series shunt, while the diode cathode is connected to the rail busbar via a fuse. A 300uH 1000A choke is to be installed in each of the pipe and rail legs.

Pullout links are required in each of the output legs. An ammeter and shunt are to be installed on the "protected" side of the surge protection devices.

4.2.4.3 Surge Protection

Between the pipe and rail legs, before the two chokes, two Dehn S 150 or equivalent in parallel shall be connected in series to a spark gap, EX-FS (120kA) with copper tungsten electrodes, or equivalent. Between the two Dehn S150 and the spark gap, a Dehn EX-FS (120kA) with copper tungsten electrodes shall be connected to earth.

On the other side of the chokes, two off Dehn S 275 or equivalent, in series, are to be connected between the pipe and rail legs. Between the two S 275 devices a connection to the earth bar is to be made via a Dehn S 275.

Next to the above, a DehnGuard S 600 or equivalent, is to be connected between the positive and negative legs.

4.2.4.4 Component Rating and Characteristics

<u>Component</u>	<u>Rating</u>
Diode	: 1000A3000PIV
Wiring	: 1000A
Chokes	: 1000A300uH
Disconnecting Links	: 1000A Continuous, 300A Load switching
Fuse	: 1000A
Shunt	: 50mV/1000A
Ammeter	: 1000A

The temperature inside the cabinet may reach 60°C. All components are to be rated for cooling under natural convection conditions.

The fuse must be fast acting and have a lower I^2t value than the diode.

Snubbing Network comprising a disc ceramic capacitor, resistor and MOV is to be installed directly across the diode.

The ammeter shall be analogue, 96mm square with an accuracy of 1.5% of maximum reading.

The two disconnecting links shall be of the knife action or of the "pull out" type (e.g. fuse holder), suitable for the easy and safe connection/disconnection of the circuit.

4.2.4.5 Spares

The following list of spares shall be provided (one of each) on the spares rack/panel.

<u>Component Description</u>	<u>No.</u>	<u>Component Reference</u>
Spark Gap	1	Dehn EX-FS Cu-W electrodes or equivalent (120kA).
MOV	1	Dehn VM130 or equivalent.
MOV	1	Dehn VM280 or equivalent.
MOV	1	Semikron SKV20 B420 or equivalent.
Fuse	1	Fast acting and 1000A.

4.2.4.6 Drawing and Component List

An electrical schematic diagram and component list must be affixed to the NDU

4.2.4.7 Guarantee

The equipment shall carry an unconditional two-year guarantee except for damages arising from vandalism, mechanical damage, external fire, flooding, or ground subsidence caused by mining or earth tremors. The unit shall operate continuously on site for a period of 30 days after which the 2-year guarantee will commence.

4.3 Transformer Rectifier Unit Enclosures

Note that all transformer rectifier enclosures are to be labelled by means of aluminium silk screen labels.

Labels shall be in upper case letters with a height of 10mm.

Labels are to be fixed to a readily visible internal surface of the enclosure by means of epoxy adhesive.

4.3.1 Buried Type

The buried type enclosure is to be manufactured from UV stabilized sheet moulding composite (SMC) with 30% glass fibre content.

The enclosure is to have the following minimum characteristics:

- Load and Impact Strength
 - SANS 558 2009 HD Roadway
 - SANS 558: EN-124 B125 (125kN)
- Opening and Depth of Enclosure
 - Daylight Opening 650mm
 - Depth 1000mm
- Metal Components and Fasteners
 - 304 Stainless Steel
- Water Ingress Protection
 - IP68
- Locking Mechanism
 - Mechanical and electronic locking system complete with alarm monitoring devices and centralised management platform
- Lid
 - Raised dual lid system for water ingress protection
- Mounting Chassis
 - The mounting chassis is to be on a worm screw mechanism to allow the installed equipment to be raised and lowered from the inside of the enclosure.

The enclosure is to be encased in 30MPa concrete such that the full circumference has minimum cover of 300mm for the full depth.

4.3.2 Mega Bunker Type

The concrete bunker is to be manufactured from concrete with a 7-day strength > 35MPa and is to be reinforced with hot dip galvanised Y12 reinforcement bars. All exposed edges are to be radiused or chamfered.

On the top of the bunker there are to be two M24 threaded sockets to accommodate lifting eye bolts which are to be supplied with the unit but are to be removable. The sockets are to be manufactured from 400 grade stainless steel and are to be welded to 50mm-by-50mm x 3mm base plate 400 grade stainless steel base plate prior to being cast into the concrete structure.

The bunker is to have a minimum height of 1430mm. There are to be two internal compartments, the upper one with an opening in the front of the unit which will accommodate a door and lower one with an opening the bottom of the unit that will accommodate incoming cable ducts. The two compartments are to be separated by means of a 304 stainless steel gland plate.

The minimum dimensions of the upper internal enclosure are to be (W) 810mm x (H) 730mm x (D) 640mm. The minimum wall thickness is to be 150mm.

The door is to be manufactured from 5mm thick hot dip galvanised mild steel. The hinges are to be internal and concealed. The door shall have three shrouded sockets to accommodate locking bolts. The locking bolts shall have a locking pattern unique to Johannesburg Water and all units shall be keyed alike.

4.3.3 Equipment Shelter Type

The enclosure is to be manufactured from reinforced concrete with a 7-day strength > 35MPa. All exposed edges are to be radiused or chamfered.

The enclosure is to have a minimum wall thickness of 90mm and to have external dimensions of (W) 2040mm x (H) 2260mm x (D) 2040mm.

The walls and roof are to be formed in a single casting whereafter the floor is to be cast in.

The enclosure is to have two lifting holes on each side to facilitate transport and placement.

The enclosure is to have a heavy duty galvanised “safe” door which is cast into the unit during manufacture.

The door lock shall have a key which is unique to Johannesburg Water. All units are to be keyed alike.

4.3.4 Transformer Rectifier Unit Enclosures Painting Requirements

Concrete structures are to be sealed and painted with an undercoat and then painted with an exterior PVA paint. The colour shall be Grey Green according to SABS 1091 H40.

4.3.5 Perimeter Security Measures for TRU Enclosures

Where required additional security measures will be installed as follows:

4.3.5.1 Outer Security Barrier

The outer security barrier is to consist of a 250mm thick 40MPa reinforced concrete slab and 700mm high bund wall topped with a 2m high Cochrane ClearVu (or equivalent) high-security barrier complete with anti-climb security spikes.

The fence uprights and gate posts are to be welded to the reinforcing cage inside the concrete. The gate is to be made of the same material as the fence with a steel square tubing frame. The gateway is to be 900mm wide and the gate is to open outwards. The hinges are to be internal and concealed. The door shall have three shrouded sockets (top middle and bottom) to accommodate locking bolts. The locking bolts shall have a locking pattern unique to Johannesburg Water and all units shall be keyed alike.

Prior to the casting of the concrete base, cable conduits and the TRU earthing system are to be installed.

110mm diameter conduits are to be installed from the pipeline and the power supply at a minimum depth of 1m. The conduit of the TRU earthing cables is to commence directly underneath the earth grid.

On completion and backfilling of the conduits and earthing installations an area of 4.5m x 4.5m is to be levelled and compacted to a density of at least 90% of the modified AASHTO maximum dry density prior to the casting of the reinforced concrete base and bund walls.

Details of this concrete structure are given elsewhere.

4.3.5.2 Remotely Monitored Electronic Intruder Detection and CCTV

4.3.5.2.1 General

This component of the work is to be carried out by a specialist sub-contractor. Tenderers are to provide full details of the subcontractor they intend using.

The system required must be able to detect, verify and deter intrusion. In addition, response services must be deployed once intrusion is verified.

The electronic security system is to consist of the following:

- Acoustic Fenceline Intruder Detection System
- Dual Passive infra-red / Ultrasonic motion detectors
- High definition CCTV cameras with motion detectors
- Remotely monitored radio
- Siren, PA System and pepper spray
- Battery back up and solar panel in vandal resistant enclosure. as supplied by Interlock systems or equivalent
- 24 hour control room monitoring
- 24 armed response.

The description of how it will operate is given below:

- The fenceline intruder detection system will detect sharp frequencies and vibrations associated with intrusion attempts on the outer security barrier. Intrusion attempts detected will send a signal to the control room and activate the CCTV cameras.
- Should the operator observe attempts to damage or penetrate the outer barrier he will be able to address the intruder via the PA system and warn him to vacate the area. Should the intruder not heed the warning, the siren will be activated and thereafter pepper spray may be deployed if required. The operator may then make an assessment of the situation and decide whether the armed response vehicle should be dispatched.
- The passive motion detectors will be positioned to detect an intruder within the primary security perimeter or on the Rocla enclosure roof. This will trigger an alarm in the control room and activate the siren. The control room operator may then immediately activate the pepper spray. The armed response vehicle will immediately be dispatched.

4.3.5.2.2 Fenceline Intruder Detection System

- The detection system shall make use of an acoustic sensor cable that is attached to the fence to detect any cutting, climbing, lifting or jumping off the fence.

- A single run of the cable in the middle of the fence shall detect intrusion attempts for the the whole height of the fence.
- The system shall utilize false alarm filtration as follows:
 - The equipment shall make use of algorithms to detect only sharp frequencies and vibrations associated with intrusion attempts while filtering the long frequencies from weather and other abient noise
 - The system shall have adjustable levels of sensitivity that may be configured as required.

4.3.5.2.3 Passive Motion Detectors

- Passive dual infrared / ultrasonic pet immune security grade motion detectors are to be the outdoor type.
- Two units will be required which will be installed in diagonally oposite corners of the enclosure against the concrete bund walls.

4.3.5.2.4 High Definition CCTV Cameras with Motion Detectors

- CCTV Cameras must be minimum 2 Mega Pixel IP Cameras
- To include varifocal lenses and IR (Infrared) motion detectors with range of 20m.
- A total of 4 cameras will be required with 2 being mounted on a 6m pole.
- Cameras to have at least 30 minutes of internal memory space.

4.3.5.2.5 Remotely Monitored Radio

- Radio must be GSM based with remote access from control room to arm and disarm the system.
- The radio must also be linked with the armed response control room.

4.3.5.2.6 Remotely Activated Siren, PA System and Pepper Spray

- The siren, PA system and pepper spray must be managed from the off-site control room through the CCTV system.

4.3.5.2.7 24 Hour Control Room Monitoring

- Only event driven CCTV monitoring shall be used - no continuous streaming. The system however must have the capability of sending hourly signals to the control room confirming health check. This must be be monitored in the control room and the software must raise an alarm if the heath check was not successful.
- The CCTV management software must have an audit trail and have alarm monitoring capability - no freeware software shall be used.

4.3.5.2.8 24 Hour Armed Response

- The Armed response is to be a separate entity from the control room. A local armed response service provider with an established footprint and track record in the area is to be utilised.
- The alarm system must be integrated with the CCTV system and must send individual signals to the armed response service provider.
- Signals to be monitored will be :
 - alarm (with zoneID),
 - pen and close (with user ID),
 - AC Fail,
 - battery low,
 - tamper alarm
 - Periodic test.

4.3.5.2.9 Battery Back-up and Solar Panel

The back-up battery **is** to have sufficient capacity to allow the entire electronic monitoring system to operate for 48 hours.

The solar panel is to have sufficient capacity to fully charge the back-up battery within 6 hours. The solar panel is to be housed inside a vandal resistant enclosure as supplied by Interlock Systems or equivalent. The solar panel is to be mounted on the roof of the TRU enclosure.

4.4 Monitoring Facilities

4.4.1 Stationary Reference Electrodes

The details of the reference electrode are as follows:

Housing	:	Porous ceramic of minimum dimensions 130mm diameter x 300mm high
Element	:	16mm ² spiral copper conductor (total length of conductor inside housing shall be a minimum of 2m)
Medium	:	copper sulphate crystals in saturated copper sulphate gel (110mm diameter by 220mm high)
Seal on housing	:	Primary cement cap and secondary epoxy resin Cap.
Cable Tail	:	Single core copper 16mm ² red PVC/PVC.
Prepackaged bag	:	Cotton bag approximately 195mm diameter x 460mm long.
Chemical backfill	:	75% hydrated gypsum, 20% Bentonite, 5%

Sodium Sulphate.

Accuracy : +/- 10mV over 15A (<3 micro-amp load)

Stability : 0°C to 55°C

4.4.2 Coupons

The coupon shall comprise a circular steel element that is flush mounted in a suitable acid, alkali, and chemically resistant epoxy. The coupon material shall be similar to the pipe material. The coupon shall be connected to a standard 2 core 2.5mm² cabtyre cable with all the connections encapsulated in epoxy. The cabtyre shall exit the coupon assembly via a suitably sized cable gland. The cabtyre cable length shall be 10m unless specified otherwise. For AC measurements the coupon shall be machined from an 11 mm diameter steel rod. For DC measurements the coupon shall be machined from a 36 mm diameter steel rod.

4.4.3 IR Free Control Card

The IR Free control card shall have termination points for the pipe negative and monitor cables, the coupon negative and monitor cables and the reference electrode cable. The control card shall serve to connect the coupon negative and pipe negative cables via a normally closed reed switch in series with a suitably rated shunt.

4.5 Monitoring and Bonding Facility Enclosures

Note that all monitoring enclosures are to be labelled by means of aluminium silk screen labels.

Labels shall be in upper case letters with a height of 10mm.

Labels are to be fixed to a readily visible internal surface of the enclosure by means of epoxy adhesive.

4.5.1 Buried Type

The enclosure is to be manufactured from UV stabilized sheet moulding composite (SMC) with 30% glass fibre content.

The enclosure is to have the following minimum characteristics:

- Load and Impact Strength
 - SANS 558 MD (4kN)
- Opening and Depth of Enclosure
 - Daylight Opening 350mm
 - Depth 600mm
- Metal Components and Fasteners
 - 304 Stainless Steel
- Water Ingress Protection
 - IP68
- Locking Mechanism

- Mechanical and electronic locking system complete with alarm monitoring devices and centralised management platform.
- Lid
 - Raised dual lid system for water ingress protection.

The enclosure is to be encased in 30MPa concrete such that the full circumference has minimum cover of 300mm for the full depth.

4.5.2 Bunker Type

The concrete bunker is to be manufactured from concrete with a 7-day strength > 35MPa and is to be reinforced with hot dip galvanised Y12 reinforcement bars. All exposed edges are to be radiused or chamfered.

On the top of the bunker there are to be two M24 threaded sockets to accommodate lifting eye bolts which are to be supplied with the unit but are to be removable. The sockets are to be manufactured from 400 grade stainless steel and are to be welded to 50mm-by-50mm x 3mm base plate 400 grade stainless steel base plate prior to being cast into the concrete structure.

The bunker is to have a minimum height of 1400mm. There are to be two internal compartments, the upper one with an opening in the front of the unit which will accommodate a door and lower one with an opening the bottom of the unit that will accommodate incoming cable ducts. The two compartments are to be separated by means of a 304 stainless steel gland plate.

The minimum dimensions of the internal enclosure are to be (W) 480mm x (H) 860mm x (D) 385mm. The minimum wall thickness is to be 150mm.

The door is to be manufactured from 5mm thick hot dip galvanised mild steel. The hinges are to be internal and concealed. The door shall have two shrouded sockets to accommodate locking bolts. The locking bolts shall have a locking pattern unique to Johannesburg Water and all units shall be keyed alike.

A white powder coated 3Cr12 chassis plate with dimensions (W) 440mm x (H) 820mm, is to be mounted on the rear wall of the bunker enclosure by means of galvanised Rawl bolts.

4.5.3 Big Head Test Post Type

The test post is to be manufactured from concrete with a 7-day strength > 35MPa and is to be reinforced with hot dip galvanised Y10 reinforcement bars. All exposed edges are to be radiused or chamfered.

The test post is to have a total height of 1400mm and is to have an enclosure at the top with internal dimensions of (W) 168mm x (H)160mm x (D)150mm. The minimum wall thickness around the enclosure is to be 65mm. The post is to have a 32mm PVC conduit installed from the base of the post to the top enclosure.

The enclosure is to have a 5mm thick HDG steel door with concealed internal hinges and a 3-lever lock. The key is to be unique to Johannesburg Water and all units are to be keyed alike.

4.5.4 Mega Big Head Test Post Type

The test post is to be manufactured from concrete with a 7-day strength > 35MPa and is to be reinforced with hot dip galvanised Y10 reinforcement bars. All exposed edges are to be radiused or chamfered.

The test post is to have a total height of 1600mm and is to have an enclosure at the top with internal dimensions of (W) 200mm x (H)240mm x (D)160mm. The minimum wall thickness around the enclosure is to be 90mm. The post is to have a 32mm PVC conduit installed from the base of the post to the top enclosure.

The enclosure is to have a 5mm thick HDG steel door with concealed internal hinges. The door shall have a shrouded socket to accommodate a locking bolt. The locking bolt shall have a locking pattern unique to Johannesburg Water and all units shall be keyed alike.

4.5.5 UPVC/Concrete Test Post

Test Posts are to be constructed from a 315mm class 16 UPVC Pipe, 1.5m in length. The internal cavity is to be filled with 50 MPa concrete up until 150mm from the top of the pipe.

Two integral flush mounted copper “banana jack” type terminals are to be cast into the concrete such that they are accessible inside the 150mm upper pipe cavity. The terminals are to be connected to pipe and reference electrode cables and are to be labelled “PIPE” and “REFERENCE” respectively. Labels shall be of the engraved type (multi-layered phenolic plastic) with black letters on a white background and are to be fixed to the concrete by means of suitable screw-in anchors.

A PVC endcap is to be fitted to the top of the UPVC pipe. The test post end cap is to be secured on opposite sides by means of two splined grub screws with a minimum diameter of 8mm. The endcap and its fastening screws shall be of such a design as to prevent ingress of rainwater.

4.5.6 Monitoring Structures Painting Requirements

Monitoring structures are to be sealed and painted with a suitable undercoat and then painted with an exterior PVA paint. The colour shall be Grey Green according to SABS 1091 H40.

4.6 Link Panels

Link panels are to be manufactured utilising 6mm thick paper based phenolic resin boards as a base. The linking system is to comprise of a 25mm by 3mm tinned copper bus bar (length determined by number of links), 80mm x 20mm x 3mm tinned copper links and 40mm x M10 brass bolts c/w nuts, washers, and spring washers.

The bus bar is to be mounted across the top of the phenolic board while terminal bolts for each of the incoming cables are to be mounted across the bottom of the board with the links in

between. The links are to be fastened to the bus bar by means of brass bolts spaced at 45mm centres.

The link panel is to be supplied with two insulated stand-off mounts comprising of 20mm diameter by 20mm thick PVC stand-off spacers and 6mm stainless steel bolts.

4.7 Insulating Flanges

An insulating flange consists of an insulating gasket, bolt sleeves and washers, approximately sized steel bolts and washers and a voltage limiting spark gap for Protection of the insulating material.

The insulating gasket between flanges to be in accordance with the following table based on pipe diameter and pressure ratings. The ID of the pipe and gasket shall in all instances be equal:

No.	Field test pressure MPa	Nominal pipe diameter mm	Insulating gasket material
1.1	Lower or equal to 2,5	All diameters	3,2mm Thick High-Density Polyethylene to PEH Hostalen GM5010 Specification, full face gasket in one piece.
1.2	Higher than 2,5	All diameters	3,2mm Thick High-Density Polyethylene to PEH Hostalen GM5010 SA Specification, full face gasket in one piece with detail "A" and "O" rings.
2.1	Lower or equal to 4,6	Smaller or equal to 1200	3,2mm Thick Fabric Reinforced Phenolic (Tested to BS5102 Appendices A-M Type III) full faced gasket in one piece with neoprene or nitrile rubber faces 0,8mm thick.
2.2	Lower or equal to 4,6	Bigger than 1200	3,2mm Thick Fabric Reinforced Phenolic (Tested to BS5102 Appendices A-M Type III) full faced gasket with not more than 2 only factory made lap joints, with neoprene or nitrile rubber faces 0,8mm thick.
No.	Field test pressure MPa	Nominal pipe diameter mm	Insulating gasket material
3.1	Lower or equal to 4,6	Smaller or equal to 1200	3,2mm Thick Fabric Reinforced Phenolic (Tested to BS5102 Appendices A-M Type III) full faced gasket in one piece with 0,8mm thick "Prolok Super" or similar Compressed

			Asbestos Fibre (to BS 1832 Grade A) full faced gaskets on each side.
3.2	Lower or equal to 4,6	Bigger than 1200	3,2mm Thick Fabric Reinforced Phenolic (Tested to BS5102 Appendices A-M Type III) full faced gasket in one piece with 0,8mm thick "Prolok Super" or similar Compressed Asbestos Fibre (to BS 1832 Grade A) full faced gaskets on each side, but with no more than two factory made lap joints.

Insulating sleeves shall be minimum of 1mm thick glass fibre reinforced polyester. Total length of sleeves is to be 2-3mm less than the length between the inside faces of steel washers. The insulating sleeves shall fit completely inside the insulating washers and extend partially inside the steel washers.

Insulating washers shall be 3,2mm thick fabric reinforced phenolic resin with OD the same as that of the machined steel washers, 2 off for each stud bolt. The ID to be sliding fit over OD of insulating sleeve.

Steel washers shall be machined with diameter and thickness to SABS 1149, Table 3.

Stud bolts and studs shall be grade 8.8 and nuts grade 8 to SABS 136. Stud bolts diameters shall be selected to the next smaller size for installation in standard drilled flanges. Stud bolts shall be machined down to the next standard smaller size and suitable smaller nut to be used. All studs, bolts and washers are to be hot dip galvanised.

Explosion-proof Spark Gap Type ExFS shall be installed across the flange faces complete with hot-dip galvanized mild steel mounting brackets to suit the flange bolt. The width of the holding bracket of the explosion-proof spark gap shall be the same as the steel insulating washers and the bottom end be rounded off to fit into the spot faced area of the valve and/or steel flange.

4.8 High Potential Magnesium Sacrificial Anodes

The anode composition shall be as follows:

Element	Percentage
Aluminium	5.30 – 6.70
Manganese	0.15 – 0.30
Zinc	2.50 – 3.50
Silicone	0.10 Maximum
Copper	0.02 Maximum
Iron	0.003 Maximum

Other	0.03 Maximum
Magnesium	Balance

The anode shall be free of blowholes, cold lap seams and any other imperfection which may detract from its performance.

The anode shall have cast into it a length of galvanised steel tube or rod running at least 90% of the anode length. The steel tube or rod shall also be suitable for the electrical connection of the anode cable to the anode and shall terminate in a recess at one end of the anode. In the case of a steel rod, this is achieved by drilling a suitable hole into the end of the rod.

The anode cables shall be 10mm² PVC/PVC (double insulated) stranded copper and of a length given in the Schedule of Rates and Quantities.

The 10mm² copper cable shall have the insulation removed for a length such that at least 25mm of copper is inserted in the tube/rod hole and flood soldered.

No mechanical connection of the anode cable to the anode is permitted.

The length of cable insulation removed shall be such that at least 20mm of insulation extends into the anode recess.

The anode recess shall be flooded with electrician's bitumen (pourable grade) which shall not be heated in excess of 180°C. The bitumen shall completely fill the recess but not spill over to the external surface of the anode.

The anode cable insulation shall extend into the bitumen. No bare copper cable shall extend outside the bitumen. The maximum cable to anode resistance shall be 1mΩ.

Under no circumstances shall the anode be handled by picking it up by its cable, nor should the cable be pulled except initially as a test after making the cable to anode connection.

The anode shall have a solution potential when buried in any type of soil more negative than -1.7V with respect to a saturated copper/copper sulphate reference electrode. The anode must be able to maintain this potential at 100mA output.

The anode capacity shall be a minimum of 1200A hrs/kg.

For buried installations, anodes shall be pre-packed in cotton bags containing a mixture of 70% gypsum, 25% bentonite and 5% sodium sulphate, in a finely powdered form.

The anode shall be placed in the centre of the bag and be completely surrounded by the gypsum/bentonite/sodium sulphate backfill.

The cotton bags shall measure approximately 250mm in diameter, and be firmly tied at the top, where the cable exits, such that the backfill does not run out.

The anodes are to be installed complete with the backfill and cotton bag. Any plastic bag over the anodes must be removed and they shall be soaked in fresh clean for 30 minutes water prior to installation.

4.9 Sacrificial Anode Mounting Bracket

For valve chamber installations, anodes are to be attached to the chamber walls by means of suitable mounting brackets and Rawl bolts. Mounting brackets are to be manufactured from non-metallic material have a design life of 25 years. The design is to be such that the anode will not make mechanical contact with the Rawl bolts.

4.10 Gradient Control Mats

Gradient control mats (GCM) are to be made of 1.2m - 2.4m sheets of 100mm x 100mm x 4mm steel wire weldmesh. The mesh is to be hot dip galvanized to SANS 121-2000.

Separate sheets are to be interconnected by means of thermit welding. A purpose made mould utilising 45g weld metal is to be used.

Cable to mesh connections are to be by thermit welding. A purpose made mould utilising 45g weld metal is to be used.

Interconnection and cable to mesh connections are to be encapsulated using a viscoelastic mastic and tape wrap system.

4.11 Gradient Control Wires

Gradient control wires shall be zinc ribbon. The composition of the zinc shall be as per ASTM B418-95 – Type II.

The zinc ribbon geometry will be of the “standard” dimensions as follows:

- Cross section (D1 x D2) 12.7 mm x 14.3 mm
- Radii (R1 x R2) 2 mm x 5 mm
- Zinc weight 0.89 kg/m
- Steel core diameter 3.3 mm
- Potential -1.1 V vs CSE
- Capacity 780 Amp hrs/kg

Zinc ribbon is to be typically supplied in 400m lengths without any joints. The material shall not crack when uncoiled for installation.

Cable connections are to be made at either end of the ribbon by means of crimped and soldered tinned copper ferules. Cable is to be 25mm² green/yellow insulated copper. Cable to ribbon connections are to be encapsulated using a viscoelastic mastic and tape wrap system.

4.12 Solid State Decoupling Devices

The SS-DCD shall be non-electrolytic, fail safe and maintenance free. Fail safe shall imply that the failure of any SS-DCD component, shall result in an open circuit system and not a short circuit system. That is, the pipeline or structure shall never be directly connected to the earthing or grounded system.

Two types of decoupling devices are used. The first type will be used to decouple the zinc ribbon from the pipeline and the second to decouple the gradient control mats from the pipeline.

Details for decoupling zinc ribbon are as follows are as follows:

- Steady state AC current: 45A
- AC fault current rating: 3.7kA for 500ms
- 50Hz AC impedance: 0.04Ω
- Lightning current rating (10/350μs)) 100kA
- DC blocking voltage: -12/+1V
- Diode PIV 1500V
- Diode forward surge current 1200A
- DC steady state current (15 min): 60A
- DC sparkover voltage: 1.0kV
- Lightning impulse voltage: 2.2kV

The decoupling device shall comprise a suitably rated diode stack capable of blocking direct current in both directions at the specified voltages.

Once the blocking voltage is exceeded, the diode stack shall be capable of conducting the steady state DC up to 60A (15-minute rating) without overheating.

The device shall exhibit a progressive, smooth transition from blocking to conduction and vice versa without commutating.

A bypass capacitor (network) shall be connected in parallel with the diode stack to conduct 50Hz AC up to the blocking voltage of the diode stack.

The capacitor and diode network shall be protected by a suitably rated spark gap for high voltage and lightning induced transients. This will include the appropriate inductance required to decouple the spark gap from the diode stack in terms of lightning protection zone standard practice.

The decoupling device shall be of open frame construction to permit maintenance / replacement of component parts. The unit will be mounted inside an IP65 rated enclosure. Component parts shall be of reputable manufacture with proven performance record and certificated test data.

The decoupling device shall be provided with two M10 terminals at each pole for the connection of 25mm² single core cables.

Details for the decoupling of gradient control mats are as follows:

- AC fault current rating: 50kA
- DC blocking voltage: 100V
- Lightning current rating 8/20: 40kA
- Lightning impulse clamping voltage: <500V
- Response time: 25ns

Equipment is to be certified by a SANAS accredited testing laboratory. Certification is to cover the following:

- **Safety Grounding**

Providing an "effective ground-fault current path" as defined in one of the following:

- 2002 NFPA 70 (US National Electrical Code - NEC), Article 250.2, and required in 250.4(A)(5)
- Canadian Standards Association CSA C22.2 No. 0.4-M1982 (reaffirmed 1999), using Canadian Electrical Code Part I, section 10-500, 10-806 as a guide.
- Providing over-voltage protection in accordance with the applicable requirements of ANSI C62.11

- **Blocking Cathodic Protection Current**

Providing DC isolation of objectionable DC ground currents from cathodic protection systems as defined in NFPA 70, Article 250.6(E)

- **Hazardous Location Use**

The PCR shall be certified for use in Class I, Division 2, Groups A, B, C, D hazardous locations by UL and C-UL, according to one of the following:

- U.S. National Electrical Code section 500-505
- UL 1604: "Electrical Equipment for Use in Class I and Class II, Division 2, and Class III Hazardous (Classified) Locations"
- CSA C22.2 No.213-M1987: "Non-Incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations"
- ATEX directive 94/9/EC, according to the standard EN50021:1999 "Electrical apparatus for potentially explosive atmospheres - Type of protection 'n'.
- **Environmental Rating**
The enclosure shall be certified to environmental rating IP68 (submersible to 2m).

4.13 Cathodic Protection Cables

Cathodic Protection cables shall be insulated and rated for voltages up to 600V/1000V and shall have stranded copper conductors in accordance with SABS 1507 or ASTM Specification B-8.

All cathodic protection cables are to be double insulated PVC/PVC or XLPE/PVC. Cable to be used for AC mitigation earthing is to be single insulated.

Colour coding is to be as follows:

Positive	:	Red
Negative	:	Black
Reference Electrode	:	Blue
Earth	:	Green/Yellow

In certain instances, multi-core power cabling might be required, such as 4 Core PVCI/PVCS/SWA/PVCS.

In certain special circumstances cables will require PVDF/HMWPE insulation.

4.14 Cable to Pipe Connections

4.14.1 Stud-Weld

Stud welding is to be carried out by means of a capacitive discharge stud welding tool. The procedure is to be performed as per the methodology specified by the equipment manufacturer. Studs are to be M8 and of suitable length for the application. Studs are to be copper plated, and nuts and washers are to be brass.

After installation, welds shall be tested by striking the weld with a 2kg hammer. Should any movement occur, the stud shall be re-welded and re-tested.

4.14.2 Thermit Weld

Thermit welds are to be performed as per manufacturer's specifications. Weld charges for pipe connections are to be no larger than 15g.

For 10mm² and 16mm² cables, a single 15g charge may be used to make the connection. For 35mm², the cable is to be split in two and welded with two 15g charges. For 70mm², the cable is to be split into four and welded with four 15g charges.

After installation, welds shall be tested by striking the weld with a 2kg hammer. Should any movement occur, the weld shall be repeated and re-tested.

4.15 Coating Repair

All coating material shall be sourced from Johannesburg Water approved suppliers. All coating applications shall be carried out in accordance with the procedures and data sheets provided by the coating material suppliers.

All cable to pipe connection and coating repairs shall be witnessed by the client's nominated representative.

5. Cathodic Protection and AC Mitigation Installations

5.1 Excavations

Prior to commencing with excavations. All necessary wayleaves are to be obtained. The proposed excavation area is to be scanned with ground penetrating radar (GPR) and the positions and depths of detected services are to be marked on the ground and recorded.

5.1.1 Cable and Anode Groundbed Trenches

Cable and anode groundbed trenches are to be excavated to a width of 300mm and depth of 1m for cables and 2.5m for anode groundbeds. Topsoil to a depth of 300mm is to be removed and stored separately.

Prior to the laying of cables or anodes inside the trench all loose rocks are to be removed from the trench floor. Trenches are to be backfilled with the native material and compacted by means of a mechanical rammer in 300mm layers. Care is to be taken when laying the first layer of backfill to ensure that no rocks or other sharp objects are placed on top of the cables.

Cable warning tape is to be installed 600mm below final ground level.

Topsoil is to be replaced as the final layer.

5.1.2 Excavation of Pipelines

Topsoil to a depth of 300mm is to be removed and stored separately. Excavation is to be carried out to a depth 300mm above the level of the pipe overt (as determined by the GPR survey). The remaining 300mm is to be carried out by hand until the pipe overt is exposed and the position and direction of the pipe is clear.

Should full circumferential excavation be required, excavation on either side is to proceed by mechanical means allowing 200mm beyond the expected pipe diameter. The remaining material is to be removed by hand. Excavation underneath the pipeline is also to be carried out by hand.

Excavations are to be backfilled with the native material and compacted by means of a mechanical rammer in 300mm layers. Care is to be taken when laying the first layer of backfill to ensure that no rocks or other sharp objects are placed on top of the cables. In cases where the pipe was found to have been installed with selected backfill or imported material, this is to be reinstated.

Cable warning tape is to be installed 600mm below final ground level.

Topsoil is to be replaced as the final layer.

5.1.3 Excavation for Gradient Control Wire Installations

Topsoil to a depth of 300mm is to be removed and stored separately. A 300mm wide trench is to be excavated to a depth of 0.8m. The floor of the excavation is to be level and free of loose stones and rocks prior to the installation of gradient control wire.

Excavations are to be backfilled with the native material and compacted by means of a mechanical rammer in 300mm layers. Care is to be taken when laying the first layer of backfill to ensure that no rocks or other sharp objects are placed on top of the wire.

Topsoil is to be replaced as the final layer.

5.1.4 Excavation for Gradient Control Mat Installations

Topsoil to a depth of 300mm is to be removed and stored separately. Excavation is to be carried out to a depth of 0.5m in a 1.2m wide border around the valve chamber. The floor of the excavation is to be level and free of loose stones and rocks prior to the installation of gradient control mesh. Where required, excavations for the installation of sacrificial anodes are to be made in the floor of the gradient control mat excavation. These are to be of sufficient size to accommodate the anodes below the mesh with a 300mm cover.

Excavations are to be backfilled with the native material and compacted by means of a mechanical rammer in 300mm layers. Care is to be taken when laying the first layer of backfill to ensure that no rocks or other sharp objects are placed on top of the mesh.

Topsoil is to be replaced as the final layer.

5.2 Concrete Encasement

5.2.1 Concrete Encasement of Cables

Prior to the pouring of concrete, the trench should be cleared of any loose rocks and the cables should be positioned in the centre of the trench. A 200mm thick layer of 30MPa concrete is to be poured over the cables. Concrete is to be allowed to set such that it can be stood on prior to backfilling and compaction proceeding.

5.2.2 Concrete Encasement of Gradient Control Mats

Once the gradient control mat has been installed and approved for backfilling by the CP Engineer, a 200mm thick layer of 30MPa concrete is to be poured over the mat. Concrete is to be allowed to set such that it can be stood on prior to backfilling and compaction proceeding.

5.3 Installation of Enclosures

5.3.1 Buried Type

Buried enclosures are to be installed as per the manufacturer's specifications ensuring that the IP68 rating is maintained.

The enclosure is to be encased in 30MPa concrete such that there is a minimum cover of 200mm of concrete for the entire circumference and the entire length of the enclosure.

5.3.2 Bunker and Mega Bunker Type

The bunker is to be placed on a 100mm thick concrete foundation of dimensions equal to the dimensions of the bunker base. Prior to the casting of the base, a 110mm diameter conduit with long radius bend is to be installed starting at a depth of 1m and coming above ground through the centre of the foundation. The horizontal portion of the conduit is to extend for a distance such that it will end in line with the concrete surround of the bunker.

After installation, a 30MPa concrete surround is to be cast around the bunker base. The surround is to extend 800mm from the bunker on all sides. The surround is to be 150mm thick and to be reinforced with 100 x 100 x 4mm weld mesh. The surround is to have a 20mm fall away from the bunker.

5.3.3 Equipment Shelter Type

The enclosure is to be placed on a 150mm thick concrete foundation of dimensions equal to the dimensions of the enclosure base. Prior to the casting of the base, 110mm diameter conduits with long radius bends are to be installed starting at a depth of 1m and coming above ground through the foundation. There are to be two incoming conduits, one to the centre of the foundation and one to a position in line with the centre of the inside surface of the enclosure wall on the left side of the entrance there is also to be a conduit installed between the position adjacent to the wall and the position at the centre of the slab. The horizontal portions of the incoming conduits are to extend for a distance such that they will end in line with the outer edge of the concrete surround.

After installation, a 30MPa concrete surround is to be cast around the enclosure base. The foundation beams are to be used as formwork for the surround. The surround is to be 150mm thick and is to have a 10mm fall away from the enclosure. The surround is to lie at a level 10mm below the door opening.

5.3.4 Big Head Test Post and uPVC Test Post Type

The test post is to be installed such that the bottom 500mm is below final ground level. The base of the test post is to be encased in 30MPa concrete covering the lower 400mm of the test post to a thickness of 300mm.

After installation, a 30MPa concrete surround is to be cast around the test post. The surround is to extend 800mm from the test post on all sides. The surround is to be 150mm thick and to be reinforced with 100 x 100 x 4mm weld mesh. The surround is to have a 20mm fall away from the test post.

5.4 Monitoring Facilities

5.4.1 Stationary Reference Electrodes

Stationary reference electrodes are to be installed adjacent to the pipeline at the 3 o'clock position. The reference electrode is to be 300mm away from the pipe wall. The reference electrode is to be soaked in water for 10 minutes prior to being installed.

Two 10mm² black double insulated cables are to be connected to the pipeline adjacent to the reference electrode installation.

The electrode is to be backfilled with the same selected backfill material that surrounds the pipeline. Cables are to be brought to the surface and terminated inside the monitoring enclosure.

5.4.2 Coupons

Coupons are to be installed immediately adjacent to pipe wall directly opposite the reference electrode.

The coupon is to be backfilled with the same selected backfill material that surrounds the pipeline.

The cable is to be brought to the surface and terminated inside the monitoring enclosure.

5.4.3 IR Free Control Cards

IR Free cards are to be installed inside the monitoring enclosure. Mountings are to be of the stand-off type to ensure that no part of the card is in contact with any part of the enclosure.

Cable terminations are to be carried out utilising the correct termination lugs as per the control card design drawing.

5.5 Continuity and Cross Bonding Facilities

5.5.1 Continuity Bonds

5.5.1.1 Flanges and Couplings

Continuity bonding of buried flanges is to be achieved by connecting a pair of black double insulated copper cables to the pipe on either side of the joint. In the case of Viking Johnson type couplings or flange adapters, a connection is also to be made to the barrel of the coupling.

For pipelines of less than 700mm diameter, the cable is to be 16mm² and for pipelines of 700mm diameter and greater, the cable is to be 35mm².

The entire pipe joint is to be coated as per the specified coating manufacturers methodologies and data sheets.

5.5.1.2 Valve Chambers

5.5.1.2.1 Internal Continuity Bond

The continuity bonding cable is to be connected to the pipe on one side of the inside of the chamber and is to be securely mounted to the wall inside galvanised conduit utilising

galvanised hospital saddles. All conduit end points are to be fitted with plastic end caps. Cable to pipe connection points are to be suitably coated.

In certain cases, continuity bonding cables may be required to terminate at a suitable link panel mounted on the chamber wall.

The length of cable and conduit, number of pipe connections and the size and configuration of link panels will be specified in the bill of quantities.

Double insulated cable is to be used. For pipelines of less than 700mm diameter, the cable is to be 16mm² and for pipelines of 700mm diameter and greater, the cable is to be 35mm².

5.5.1.2.2 External Continuity Bond

The pipe is to be excavated immediately adjacent to the chamber wall and a trench 1m deep is to be excavated around the chamber adjacent to the wall.

The continuity bonding cables are to be connected to the pipe on one side of the outside of the chamber and are to be routed around the chamber inside the trench. Cable to pipe connection points are to be suitably coated.

The length of cable and number of pipe connections will be specified in the bill of quantities.

Parallel double insulated cables are to be used. For pipelines of less than 700mm diameter, the cable is to be 16mm² and for pipelines of 700mm diameter and greater, the cable is to be 35mm².

5.6 Insulating Flange Materials

Insulating flange materials are to be installed by a qualified fitter. The torque settings prescribed for the given flange set are to be met but not exceeded.

The explosion proof spark gap is to be installed on the upper-most stud on the flange set.

5.7 Sacrificial Anodes

5.7.1 Buried Installation

Sacrificial anodes are to be installed vertically inside the excavated trench such that the top is 1m below final ground level. Prior to installation, anodes are to be removed from any plastic packaging and soaked in clean fresh water for 15 minutes prior to installation. Anodes are never to be lifted or moved by their cable tails.

5.7.2 Valve Chamber Installation

For valve chamber installations, anodes are to be attached to the chamber walls by means of suitable mounting brackets and Rawl bolts. Anodes are to be mounted horizontally and pipe invert depth or at the level of the underside of and valves or fittings, whichever is lower.

Cables are to be routed to the link panel in suitably mounted galvanised conduits.

5.8 Impressed Current Groundbeds

Anode and spacer canisters are to be carefully lowered into the trench using suitable slings. The cable is to be kept clear to prevent it being damaged in the process. The cable is not to be used to manoeuvre the anode canisters in any way.

The ring main cable is to be laid out on the edge of the trench and the anode tails are to be alternately spliced to each leg of the ring main. The cable jointing kits and cables are to be secured in position and not moved until the epoxy resin has set.

Prior to the ring main being laid into the trench, the anode and spacer canisters are to be backfilled with native material excluding any rocks larger than 30mm diameter such that they have 100mm cover. Thereafter the cables are to be laid in the trench and covered with 100mm of similarly screened material before the remaining backfilling is carried out.

5.9 Gradient Control Mats

The GCM's are to be installed around the outside of valve chambers at a depth of 0.5m in a 1.2m wide border with a 200mm thick 30MPa concrete slab over it. In addition, the same mesh is to be installed underneath the chamber floor. In the case of existing chambers, the weld mesh is to be installed on the chamber floor and then covered with a 50mm concrete screed.

GCM's are to be assembled on site to the required sizes with the constituent weld mesh sheets being joined by means of thermit welds at 400mm spacing.

Magnesium anodes are to be installed horizontally 300mm below the outer grid and connected to the grid by means of 16mm² PVC/PVC insulated cable.

The separate components of the GCM (the surround and sub-floor mats) are to be connected to the pipeline by via a suitable link panel installed inside the valve chamber. Pipe connection cables are to be black 16mm² PVC/PVC insulated copper cables. GCM connection cables are to be green/yellow 16mm² PVC insulated copper cables.

Connections between the weld mesh and the cables is to be by means of thermit welding.

All thermit welded GCM connections are to be completely sealed using a viscoelastic mastic and tape wrap system. The entire heat affected portion of the weld mesh and 50mm beyond the start of the cable insulation is to be encapsulated.

5.10 Gradient Control Wires

Gradient control wire (zinc ribbon) is to be carefully unrolled from the coil in such a way that no twisting or kinking of the material occurs. The material is to be laid flat and straight on the trench floor.

Cable connections are to be made at either end of the ribbon by means of crimped and soldered tinned copper ferules. Cable is to be 25mm² green/yellow insulated copper. Cable to ribbon connections are to be encapsulated using a viscoelastic mastic and tape wrap system.

The gradient control wires are to be backfilled with native material excluding any rocks larger than 30mm diameter such that they have 100mm cover. Thereafter the remaining backfilling is carried out. Cable warning tape is to be installed 300mm above the level of the wire installation.

5.11 Solid State Decoupling Devices

Decoupling devices will be installed inside enclosures at locations along the AC-affected portions of the pipelines, through which the gradient control wires will be connected to the pipelines.

The devices are to be securely mounted in the designated location using suitable expansion bolts.

Cables shall be terminated by means of lugs. insulated by means of heat shrink sleeves or slip-on rubber shrouds colour-coded to match the cable insulation.

All terminals shall be suitably labelled and be completely accessible after completion of all wiring.

Terminals shall be provided with lock nuts and or spring washers.

5.12 Cables

Cables are to be carefully unrolled from the coil in such a way that no twisting or kinking occurs. Cables are to be laid flat and straight on the trench floor.

Cables are to be backfilled with native material excluding any rocks larger than 30mm diameter such that they have 100mm cover. Thereafter the remaining backfilling is carried out.

Cable warning tape is to be installed 300mm above the level of the cable installation.

5.13 Installation of Cable to Pipe Connections

Cable to pipe connections are to be by means of stud welding or thermit welding.

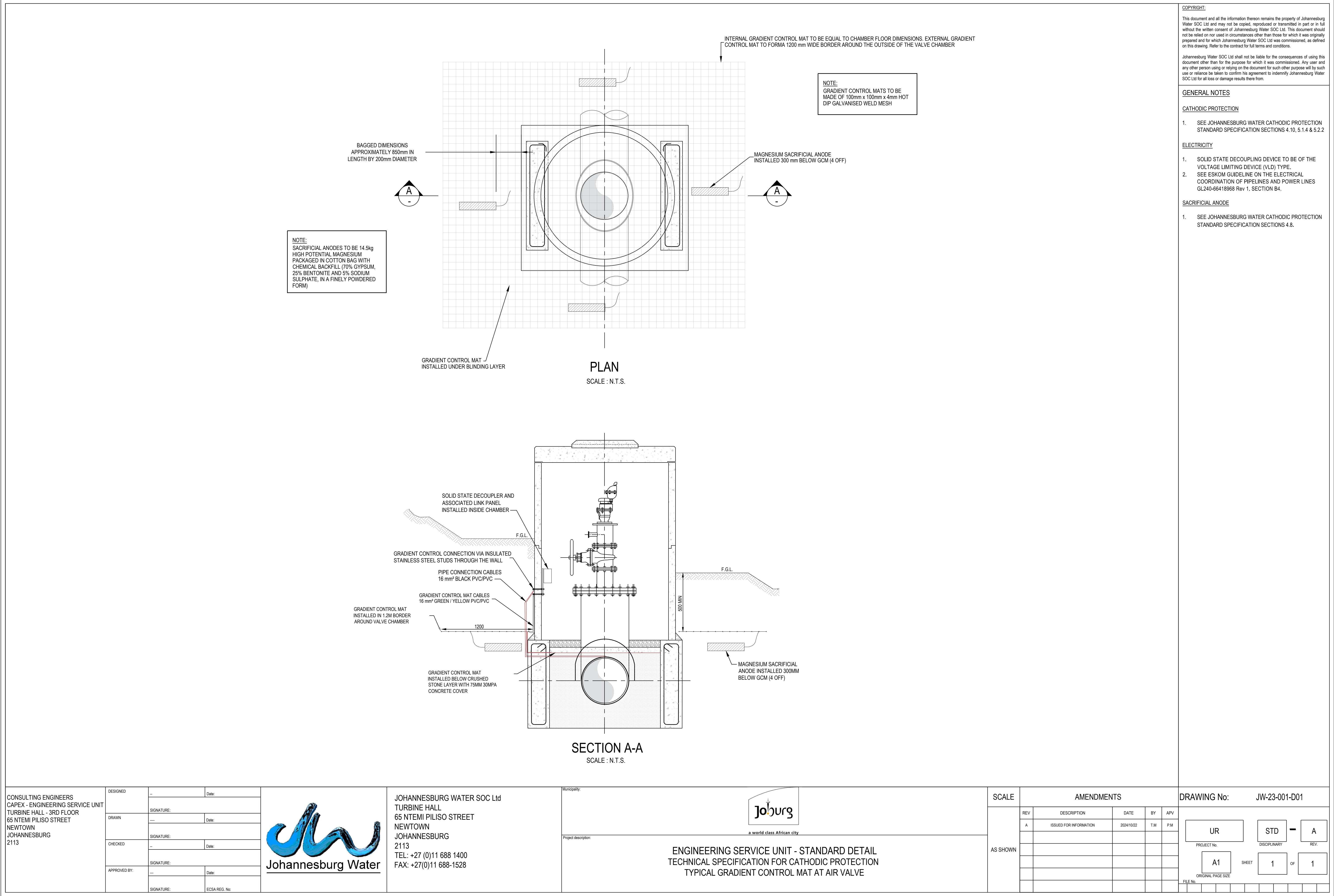
Installations are to be carried out according to the manufacturer's specifications by a technician who has undergone training from the manufacturer and has a valid certificate to indicate this.

5.14 Installation of Coating Repair Materials

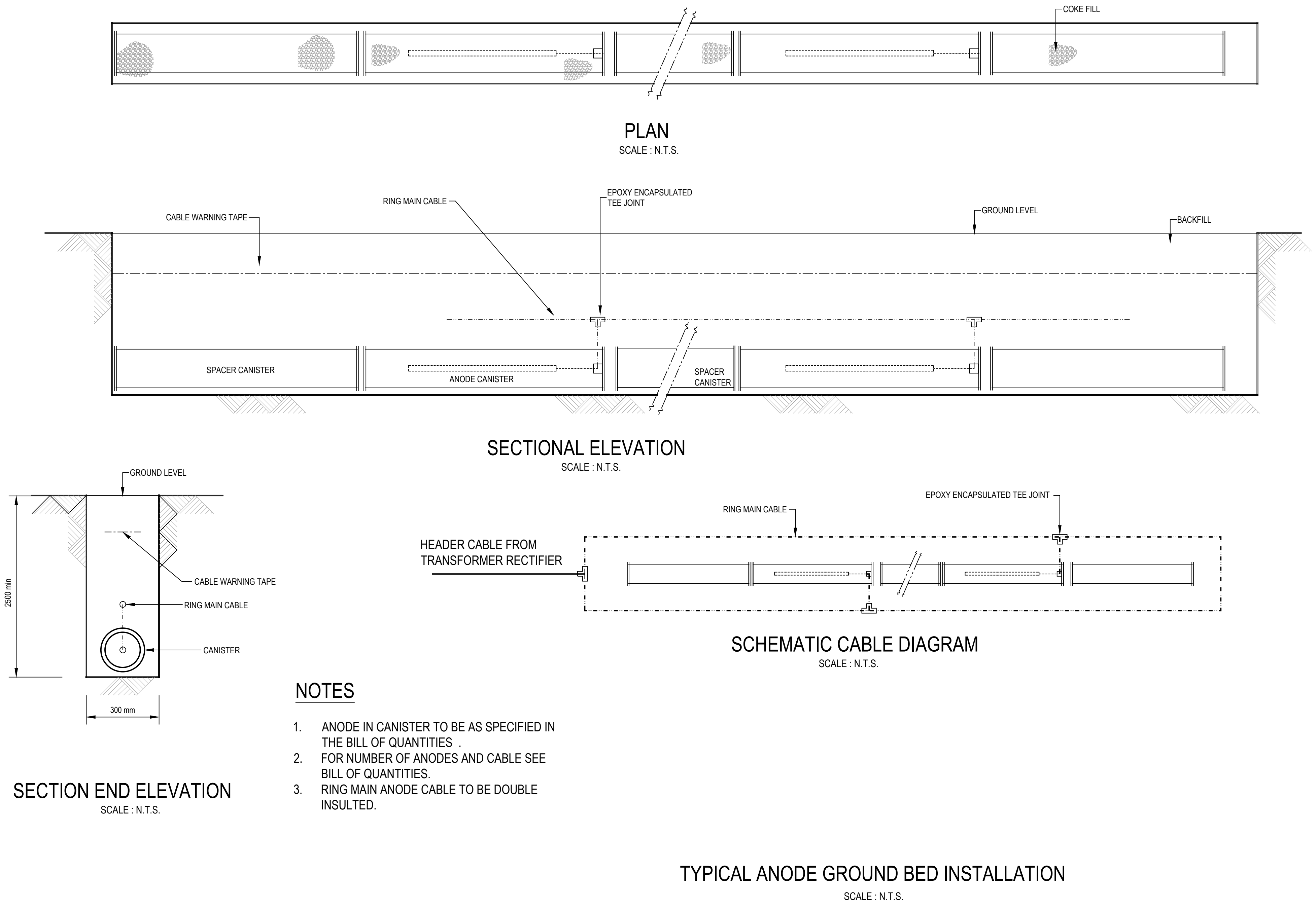
Coating repair applications are to be carried out according to the manufacturer's specifications by a technician who has undergone training from the manufacturer and has and has a valid certificate to indicate this.

Appendix 1 : Specification Drawings

<u>Drawing Number</u>	<u>Drawing Title</u>
JW-23-01-D01 Rev 0:	Typical Air Valve Gradient Control Mat
JW-23-01-D02 Rev 0:	Typical Scour Valve Gradient Control Mat
JW-23-01-D03 Rev 0:	Typical Equipment Shelter Type TRU Enclosure
JW-23-01-D04 Rev 0:	Typical Mega Bunker Type TRU enclosure
JW-23-01-D05 Rev 0:	Typical Buried Type TRU Enclosure
JW-23-01-D06 Rev 0:	Typical Bunker Type Monitoring Enclosure
JW-23-01-D07 Rev 0:	Typical Buried Type Monitoring Enclosure
JW-23-01-D08 Rev 0:	Typical Big Head Type Monitoring Enclosure
JW-23-01-D09 Rev 0:	Typical Large Chamber Gradient Control Mat
JW-23-01-D10 Rev 0:	Typical Valve Chamber Anode Installation
JW-23-01-D11 Rev 0:	Typical Valve Chamber Continuity Bond (Internal)
JW-23-01-D12 Rev 0:	Typical Valve Chamber Continuity Bond (External)
JW-23-01-D13 Rev 0:	Typical Link Panel
JW-23-01-D14 Rev 0:	Typical PVC Type Monitoring Enclosure
JW-23-01-D15 Rev 0:	Typical Electrical Schematic for a Switch Mode Cathodic Protection Rectifier Unit
JW-23-01-D16 Rev 0:	Typical Electrical Schematic for a Single-Phase Manual Tap Change Transformer Rectifier Unit
JW-23-01-D17 Rev 0:	Typical Electrical Schematic for a Three Phase Manual Tap Change Transformer Rectifier Unit
JW-23-01-D18 Rev 0:	Typical Electrical Schematic for a Three Phase Thyristor Controlled Transformer Rectifier Unit
JW-23-01-D19 Rev 0:	Typical Electrical Schematic for a Three Phase Thyristor Controlled Forced Drainage Unit
JW-23-01-D20 Rev 0:	Typical Electrical Schematic for a Natural Drainage Unit
JW-23-01-D21 Rev 0:	Typical Anode Groundbed Installation
JW-23-01-D22 Rev 0:	Typical TRU Enclosure Perimeter Security
JW-23-01-D23 Rev 0:	Typical TRU Enclosure Perimeter Security – Concrete Foundation Detail



COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.



ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Municipality:	 a world class African city	SCALE	AMENDMENTS					DRAWING No: JW-23-001-D021
	DRAWN	---	Date:						REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No: STD DISCIPLINARY A REV. A1 SHEET 1 OF 1 FILE No: <

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

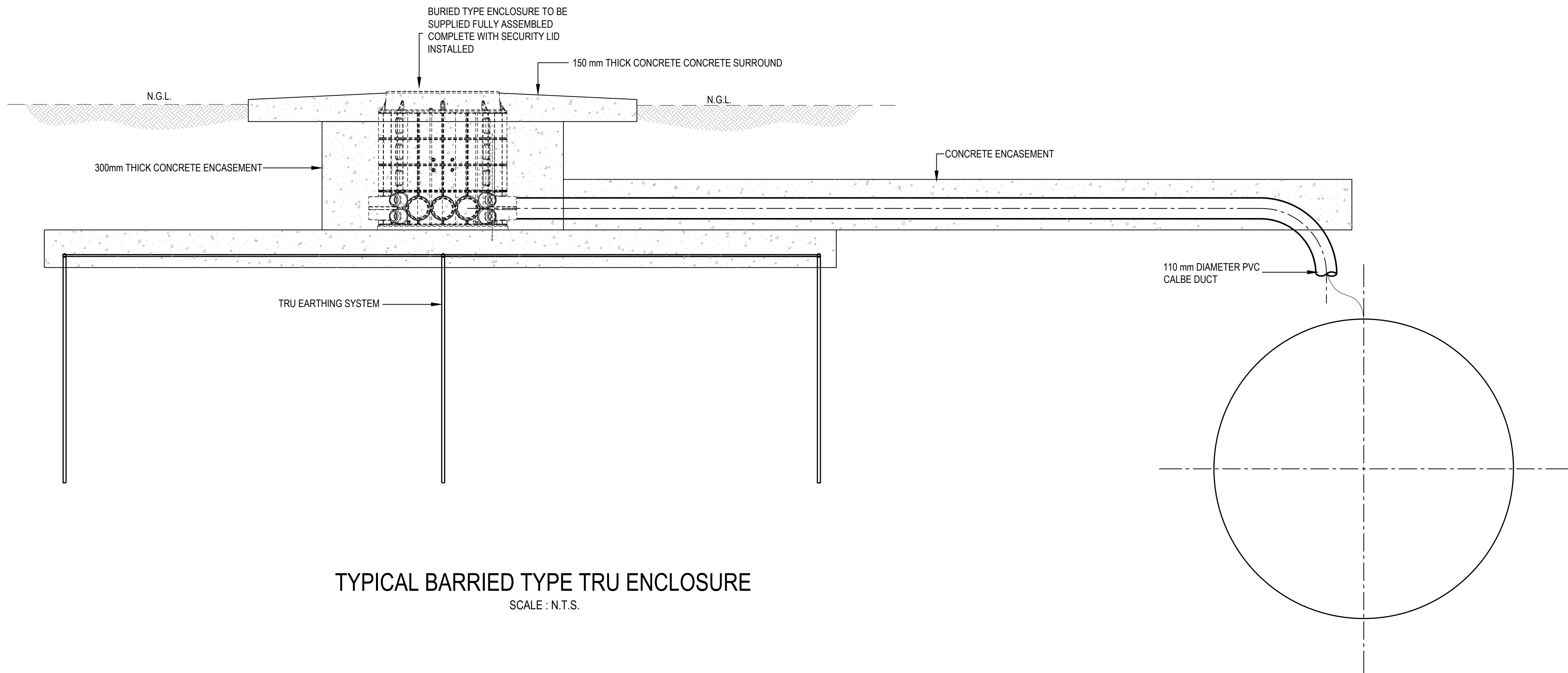
REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. MINIMUM OPENING TO BE 650mm DIAMETER AND MINIMUM INTERNAL DEPTH TO BE 1000mm.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.3.1 AND 5.3.1.

ELECTRICITY

CABLE SIZES AND LENGTHS

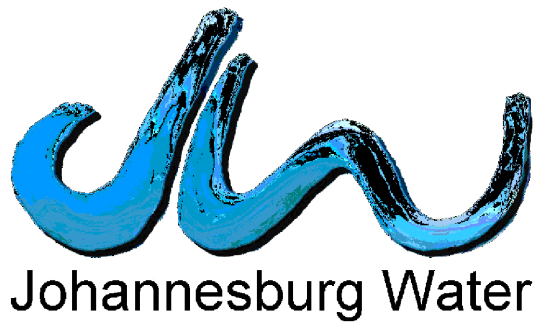
1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.



ISSUED FOR INFORMATION

CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:
DRAWN	---	Date:
CHECKED	---	Date:
APPROVED BY:	---	Date:
SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



a world class African city

Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL BARRIED TYPE TRU ENCLOSURE

SCALE

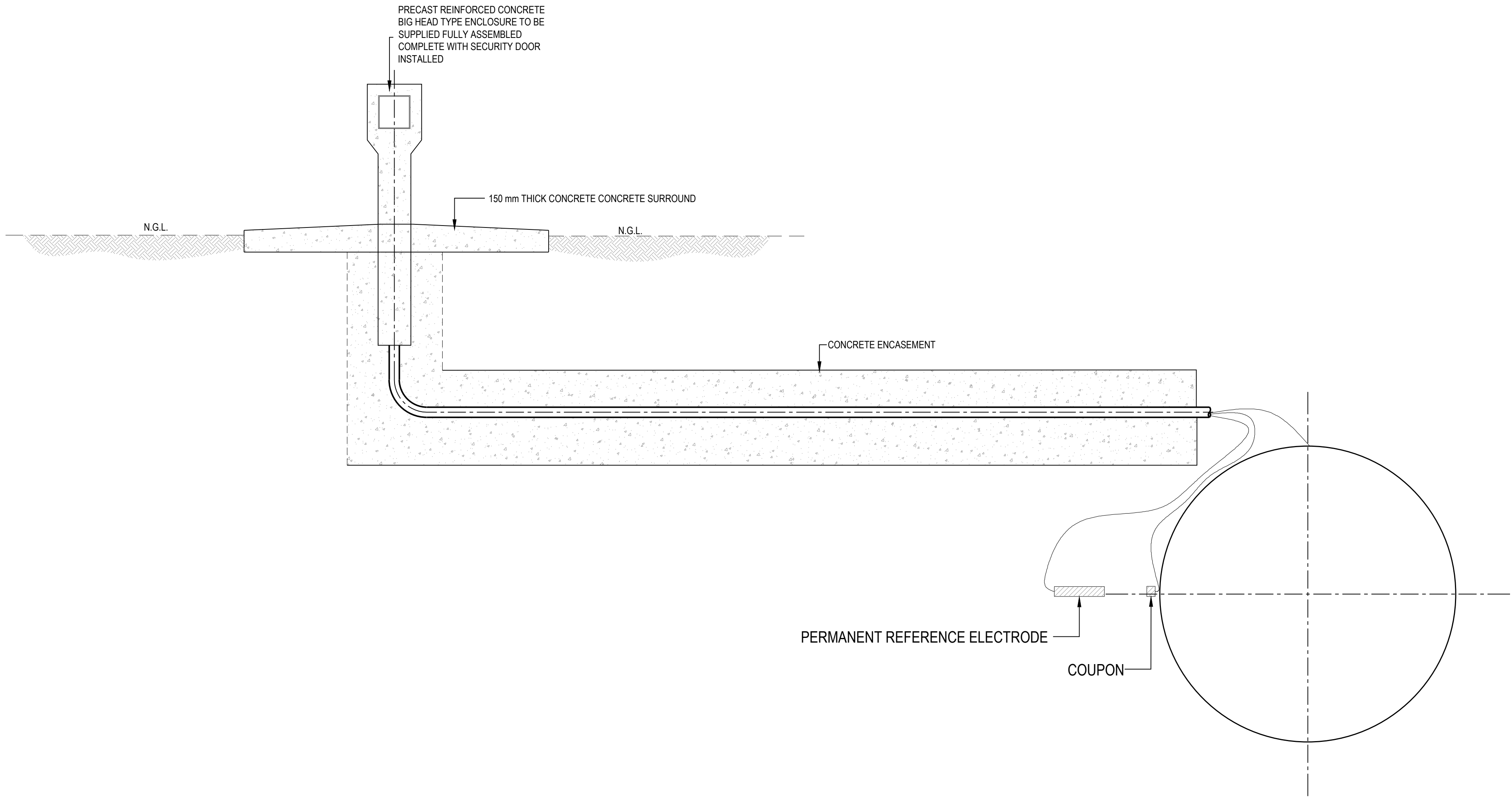
AMENDMENTS

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR INFORMATION			

AS SHOWN

DRAWING No: JW-23-001-D05

UR	STD	-	A
PROJECT No:	DISCIPLINARY	REV.	
A1	SHEET	1	OF 1
ORIGINAL PAGE SIZE			
FILE No:			



TYPICAL BIG HEAD TYPE MONITORING ENCLOSURE

SCALE : N.T.S.

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. NORMAL BIG HEAD TYPE : MINIMUM INTERNAL DIMENSIONS OF UPPER ENCLOSURE TO BE (W) 168mm x (H) 160mm x (D) 150mm WITH MINIMUM 65mm WALL THICKNESS AROUND ENCLOSURE, TOTAL TEST POST HEIGHT OF 1400mm. MEGA BIG HEAD TYPE : MINIMUM INTERNAL DIMENSIONS OF UPPER ENCLOSURE TO BE (W) 200mm x (H) 240mm x (D) 160mm WITH MINIMUM 90mm Wall THICKNESS AROUND ENCLOSURE, TOTAL TEST POST HEIGHT OF 1600mm.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.5.2, 4.5.3 AND 5.3.4.

ELECTRICITY

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

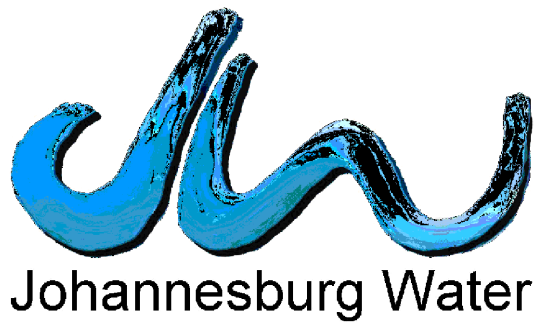
ELECTRODE AND COUPON

1. BAGGED DIMENSIONS APPROXIMATELY 460mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .

ISSUED FOR INFORMATION

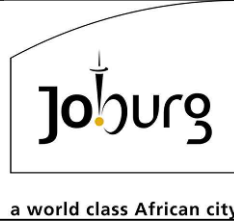
CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:
DRAWN	---	Date:
CHECKED	---	Date:
APPROVED BY:	---	Date:
SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL BIG HEAD TYPE MONITORING ENCLOSURE

SCALE

AMENDMENTS

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR PRELIMINARY DESIGN REPORT	2024/10/22	T.M	P.M

DRAWING No:

JW-23-001-D08

UR	STD	A
PROJECT No:	DISCIPLINARY	REV.
A1	1	1
ORIGINAL PAGE SIZE	SHEET	OF
FILE No:		

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. MINIMUM INTERNAL DIMENSIONS OF UPPER ENCLOSURE TO BE (W) 480mm x (H) 860mm x (D) 385mm, WALL THICKNESS OF 150mm. MINIMUM OVERALL UNIT HEIGHT OF 1400 mm.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.3.3 AND 5.3.3.
3. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

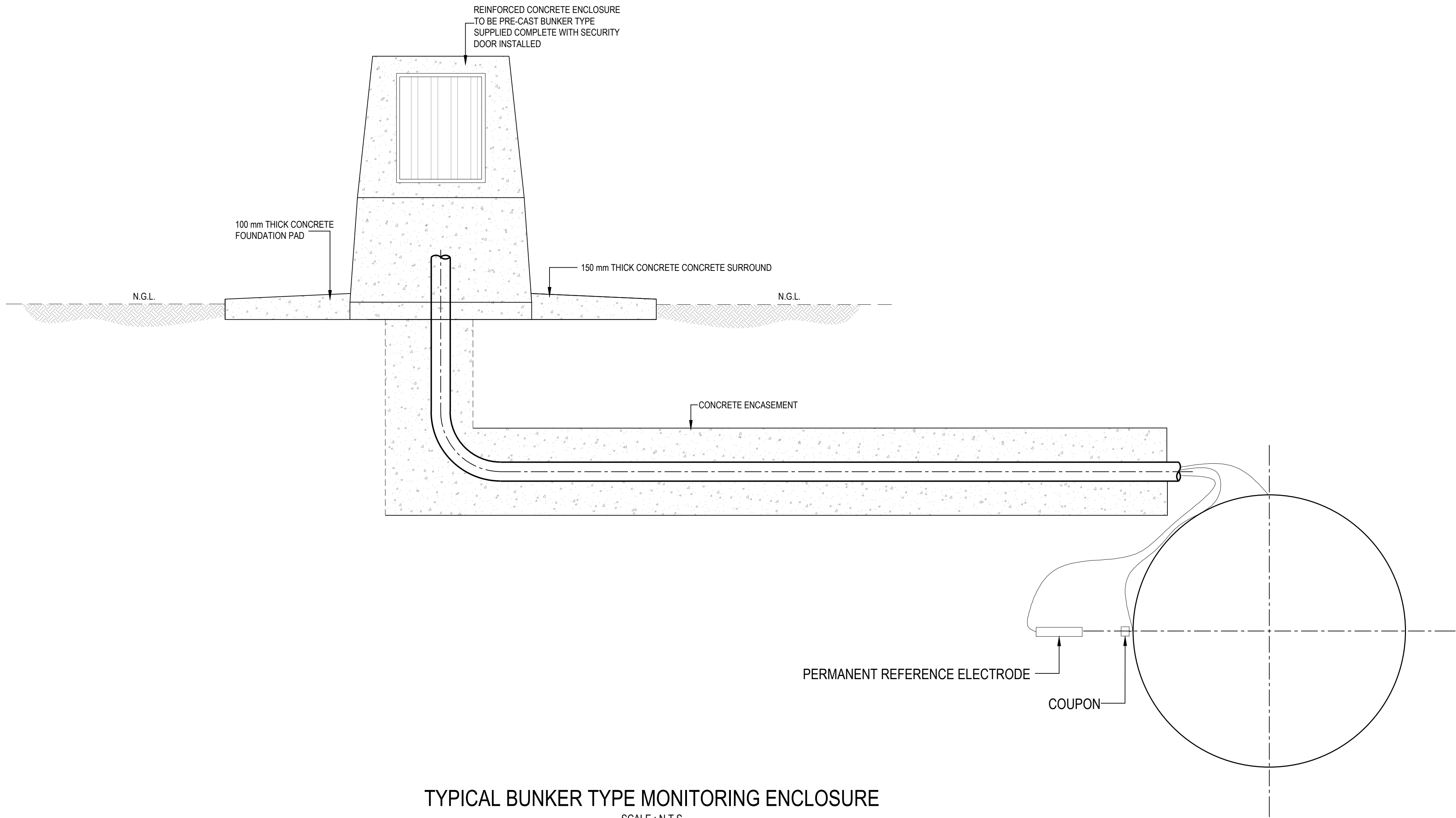
ELECTRICITY

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

ELECTRODE AND COUPON

1. BAGGED DIMENSIONS APPROXIMATELY 460 mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .



TYPICAL BUNKER TYPE MONITORING ENCLOSURE
SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:		JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Project description:	 a world class African city	SCALE	AMENDMENTS						DRAWING No: JW-23-001-D06										
	DRAWN	---	Date:						REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No. A1 ORIGINAL PAGE SIZE FILE No.	STD - A DISCIPLINARY SHEET 1 OF 1										
	CHECKED	---	Date:						A	ISSUED FOR INFORMATION															
	APPROVED BY:	---	Date:						N.T.S.																
		SIGNATURE:	---																						
		SIGNATURE:	---																						
		SIGNATURE:	ECSA REG. No:												FILE No.										
ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL BUNKER TYPE MONITORING ENCLOSURE										PROJECT No.						DISCIPLINARY		REV.							
										A1		SHEET		1		OF		1							

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

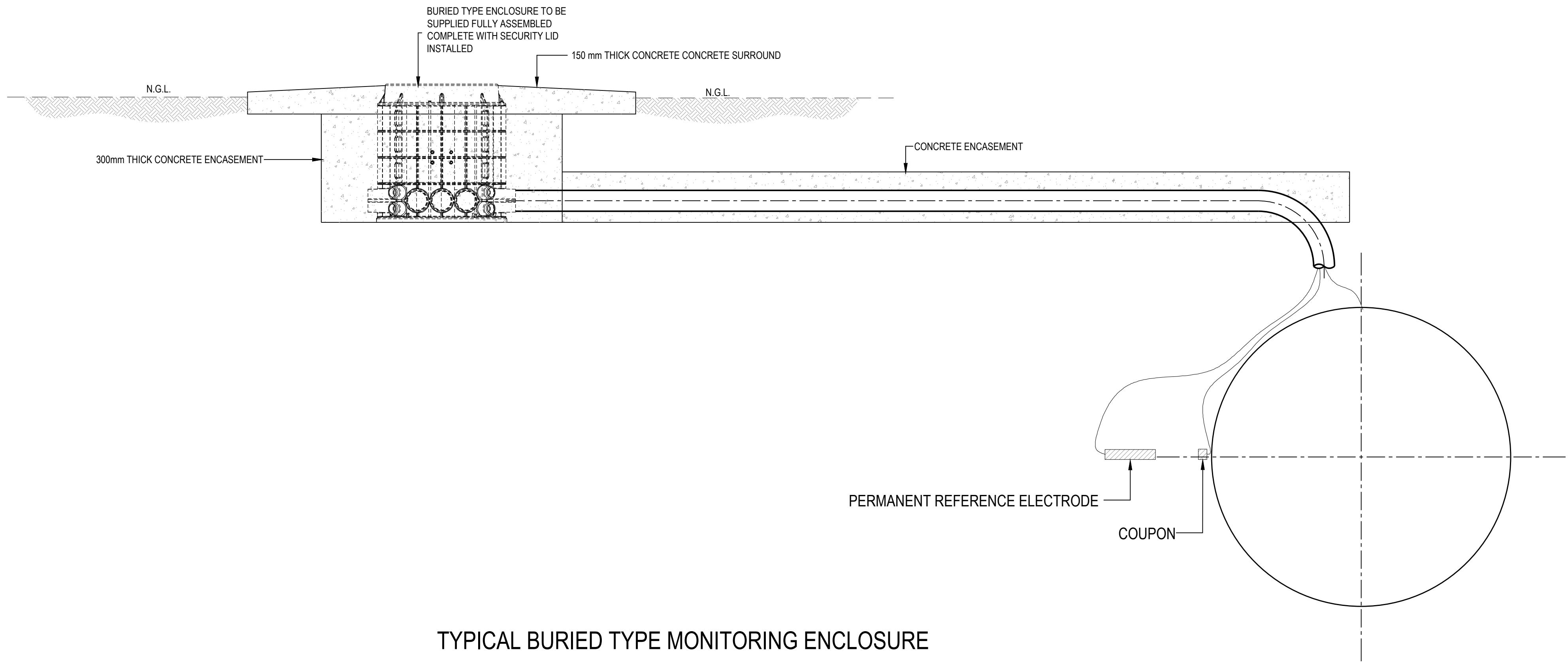
REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. MINIMUM OPENING TO BE 650mm DIAMETER AND MINIMUM INTERNAL DEPTH TO BE 1000mm.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.3.1 AND 5.3.1.

ELECTRICITY

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.



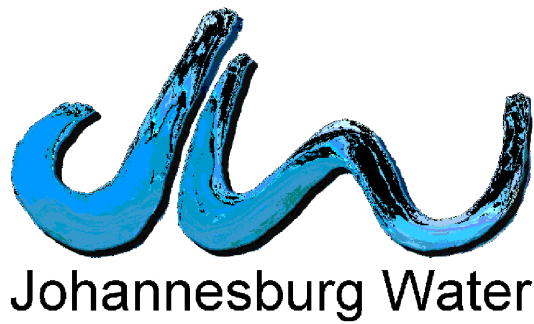
TYPICAL BURIED TYPE MONITORING ENCLOSURE

SCALE : N.T.S.

ISSUED FOR INFORMATION

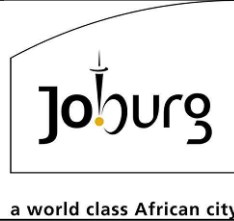
CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:	
	SIGNATURE:		
DRAWN	---	Date:	
	SIGNATURE:		
CHECKED	---	Date:	
	SIGNATURE:		
APPROVED BY:	---	Date:	
	SIGNATURE:		
		ECSA REG. No:	



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL BURIED TYPE MONITORING ENCLOSURE

SCALE

AMENDMENTS

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR PRELIMINARY DESIGN REPORT			

DRAWING No:

JW-23-001-D07

UR	STD	-	A
PROJECT No:	DISCIPLINARY	REV.	
A1	SHEET	1	OF 1
ORIGINAL PAGE SIZE			
FILE No:			

This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.

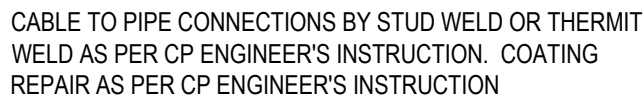
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

CATHODIC PROTECTION

1. GRADIENT CONTROL MAT TO BE 100mm x 100mm x 4mm
HOT DIP GALVANIZED WELD MESH.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION
STANDARD SPECIFICATION SECTIONS 4.10, 5.1.4 & 5.2.2

1. SOLID STATE DECOUPLING DEVICE TO BE OF THE VOLTAGE LIMITING DEVICE (VLD) TYPE.
2. SEE ESKOM GUIDELINE ON THE ELECTRICAL COORDINATION OF PIPELINES AND POWER LINES GL240-66418968 Rev 1. SECTION B4.

1. SACRIFICIAL ANODES TO BE 14.5KG HIGH POTENTIAL MAGNESIUM PACKAGED IN COTTON BAG WITH CHEMICAL BACKFILL (70% GYPSUM, 25% BENTONITE AND 5% SODIUM SULPHATE, IN A FINELY POWDERED FORM)
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.8.



SCALE : N.T.S.

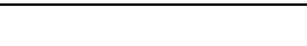
CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:
	SIGNATURE:		
	DRAWN	---	Date:
	SIGNATURE:		
	CHECKED	---	Date:
	SIGNATURE:		
APPROVED BY:	---	Date:	
	SIGNATURE:		
	ECSA REG. No:		



Johannesburg Water

JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



a world class African city

Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL CHAMBER CONTINUITY BOND (EXTERNAL)

SCALE	AMENDMENTS					DRAWING No: JW-23-001-D012	
	REV	DESCRIPTION	DATE	BY	APV		
N.T.S.	A	ISSUED FOR INFORMATION					

UR		STD	-	A
PROJECT NO.		DISCIPLINARY		REV.
A1	SHEET	1	OF	1
ORIGINAL PAGE SIZE				
FILE No.				

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

CATHODIC PROTECTION

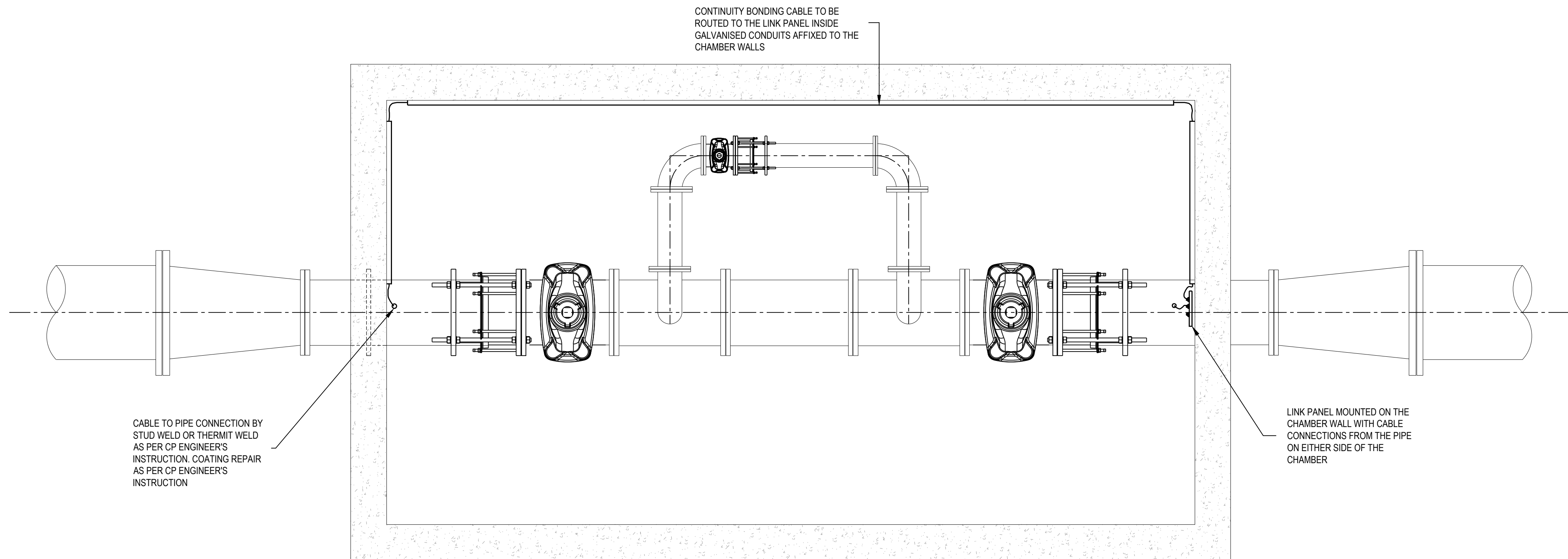
- GRADIENT CONTROL MAT TO BE 100mm x 100mm x 4mm HOT DIP GALVANIZED WELD MESH.
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.10, 5.1.4 & 5.2.2

ELECTRICITY

- SOLID STATE DECOUPLING DEVICE TO BE OF THE VOLTAGE LIMITING DEVICE (VLD) TYPE.
- SEE ESKOM GUIDELINE ON THE ELECTRICAL COORDINATION OF PIPELINES AND POWER LINES GL240-66418968 Rev 1, SECTION B4.

SACRIFICIAL ANODE

- SACRIFICIAL ANODES TO BE 14.5KG HIGH POTENTIAL MAGNESIUM PACKAGED IN COTTON BAG WITH CHEMICAL BACKFILL (70% GYPSUM, 25% BENTONITE AND 5% SODIUM SULPHATE, IN A FINELY POWDERED FORM)
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.8.



TYPICAL CHAMBER CONTINUITY BOND (INTERNAL)

SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:
DRAWN	---	Date:
CHECKED	---	Date:
APPROVED BY:	---	Date:
SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



a world class African city

Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL CHAMBER CONTINUITY BOND (INTERNAL)

SCALE

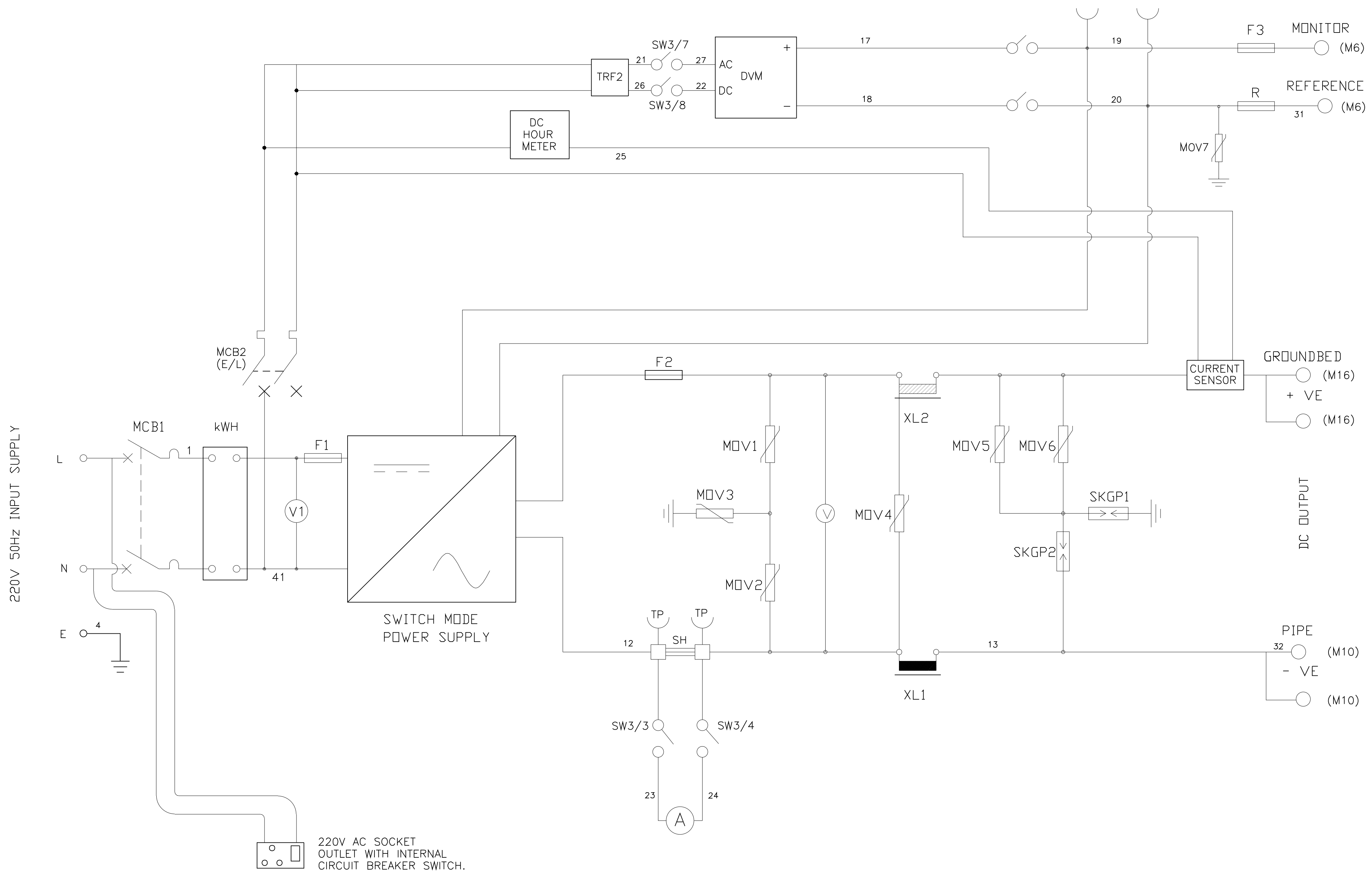
AMENDMENTS

N.T.S.

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR INFORMATION			

DRAWING No: JW-23-001-D011

UR	STD	A
PROJECT No:	DISCIPLINARY	REV.
A1	1	1
ORIGINAL PAGE SIZE		
FILE No:		



TYPICAL ELECTRICAL SCHEMATIC FOR SWITCH MODE CATHODIC PROTECTION RECTIFIER UNIT

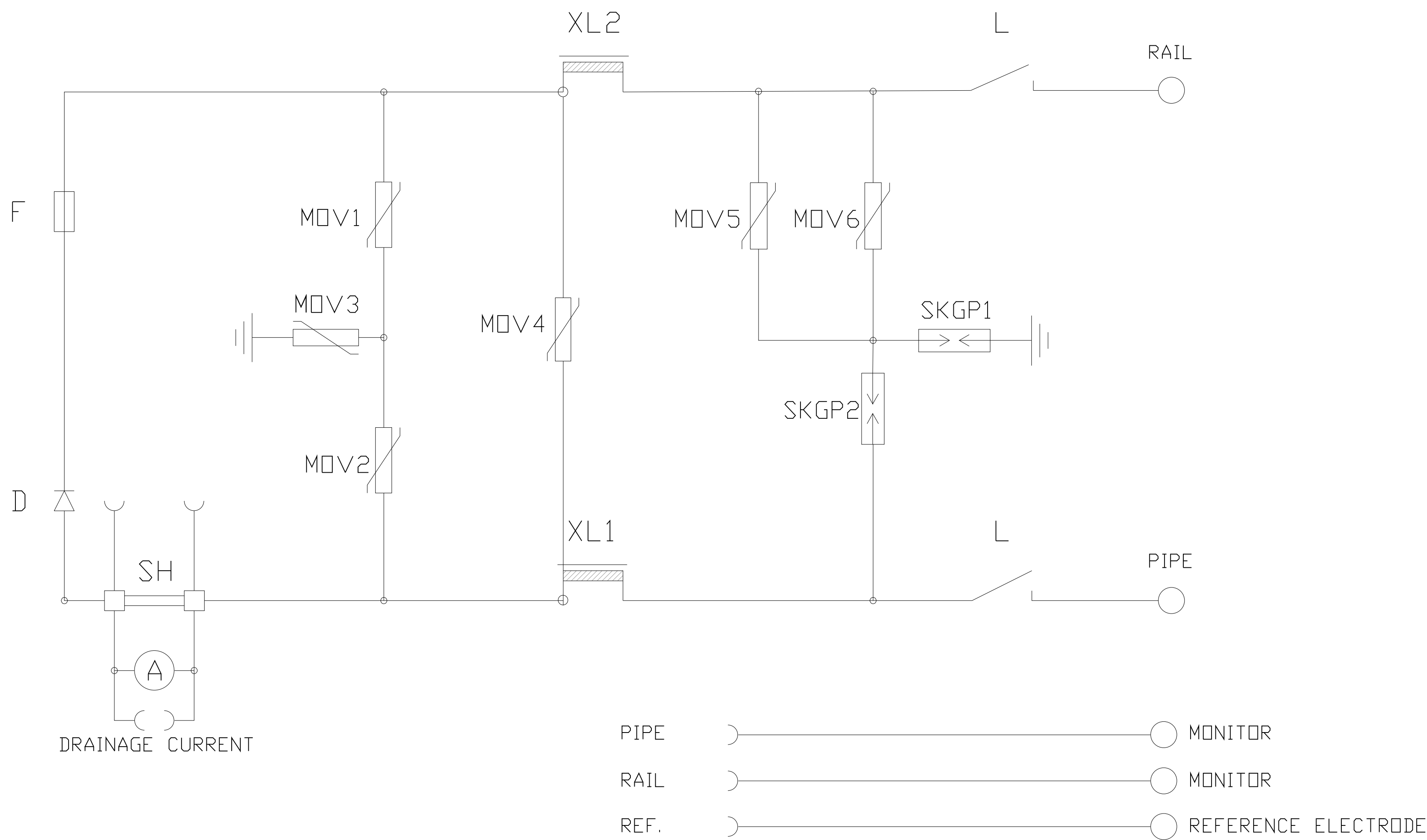
SCALE : N.T.S.

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Municipality:  a world class African city	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL ELECTRICAL SCHEMATIC FOR SWITCH MODE CATHODIC PROTECTION RECTIFIER UNIT	SCALE N.T.S.	AMENDMENTS					DRAWING No: JW-23-001-D015		
	DRAWN	---	Date:						REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No. A1 SHEET ORIGINAL PAGE SIZE FILE No.		
	CHECKED	---	Date:						A	ISSUED FOR INFORMATION						
	APPROVED BY:	---	Date:													
	SIGNATURE:	---	Date:													
	SIGNATURE:	---	ECOSA REG. No:													

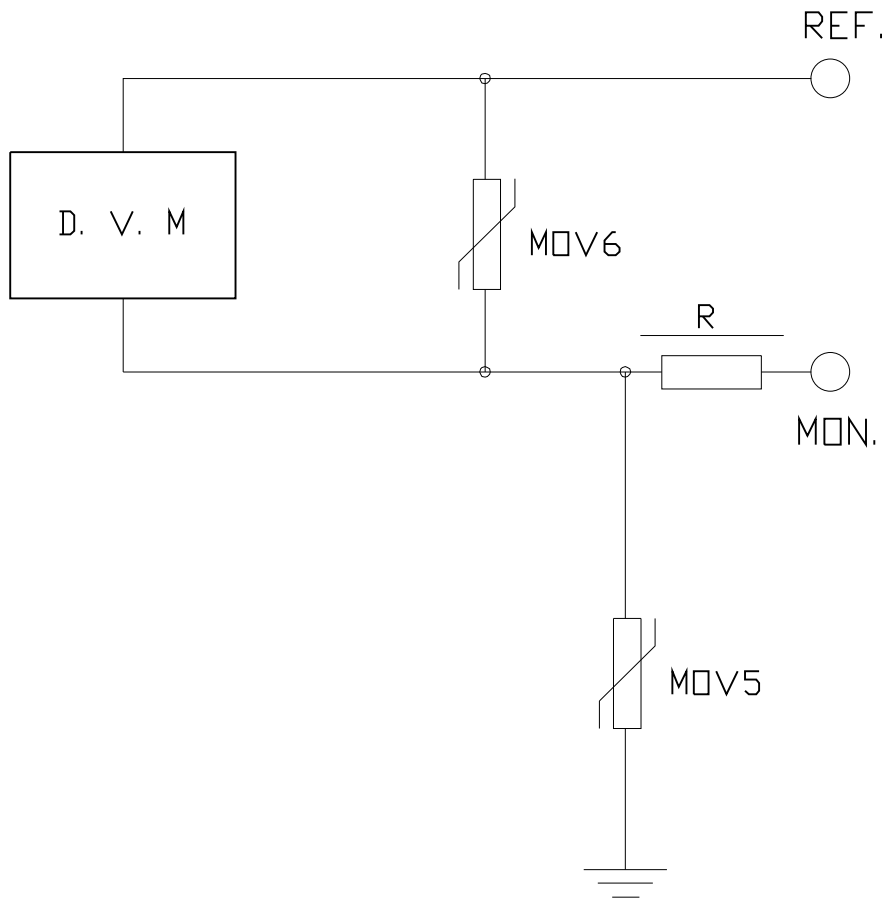
COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.



TYPICAL ELECTRICAL SCHEMATIC OF NATURAL DRAINAGE UNIT
SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL ELECTRICAL SCHEMATIC OF NATURAL DRAINAGE UNIT	 a world class African city	SCALE	AMENDMENTS					DRAWING No: JW-23-001-D020																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	DRAWN	---	Date:					REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No: STD DISCIPLINARY A REV. A1 SHEET 1 OF 1 ORIGINAL PAGE SIZE FILE No:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	CHECKED	---	Date:					A	ISSUED FOR INFORMATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	APPROVED BY:	---	Date:					N.T.S.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	SIGNATURE:	---	Date:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
SIGNATURE:	---	ECSA REG. No:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			</



SCALE : N.T.S.

Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

RECTIFIER UNIT

- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTION 4.2.1

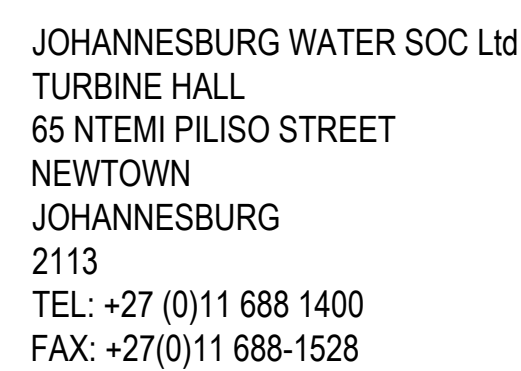
CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	--	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Municipality:  a world class African city	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL ELECTRICAL SCHEMATIC OF THREE PHASE TAP CHANGE TRANSFORMER RECTIFIER UNIT	SCALE N.T.S.	AMENDMENTS						DRAWING No: JW-23-001-D017 UR PROJECT No: A1 SHEET 1 OF 1 DISCIPLINARY REV ORIGINAL PAGE SIZE FILE No:
	DRAWN	----	Date:						REV	DESCRIPTION	DATE	BY	APV		
	CHECKED	--	Date:						A	ISSUED FOR INFORMATION					
	APPROVED BY:	---	Date:												
	SIGNATURE:														
	SIGNATURE:		ECSA REG. No:												

This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.

[illegible]

SCALE : N.T.S.

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:
		SIGNATURE:	
	DRAWN	---	Date:
		SIGNATURE:	
	CHECKED	---	Date:
		SIGNATURE:	
	APPROVED BY:	---	Date:
		SIGNATURE:	ECSA REG. No:



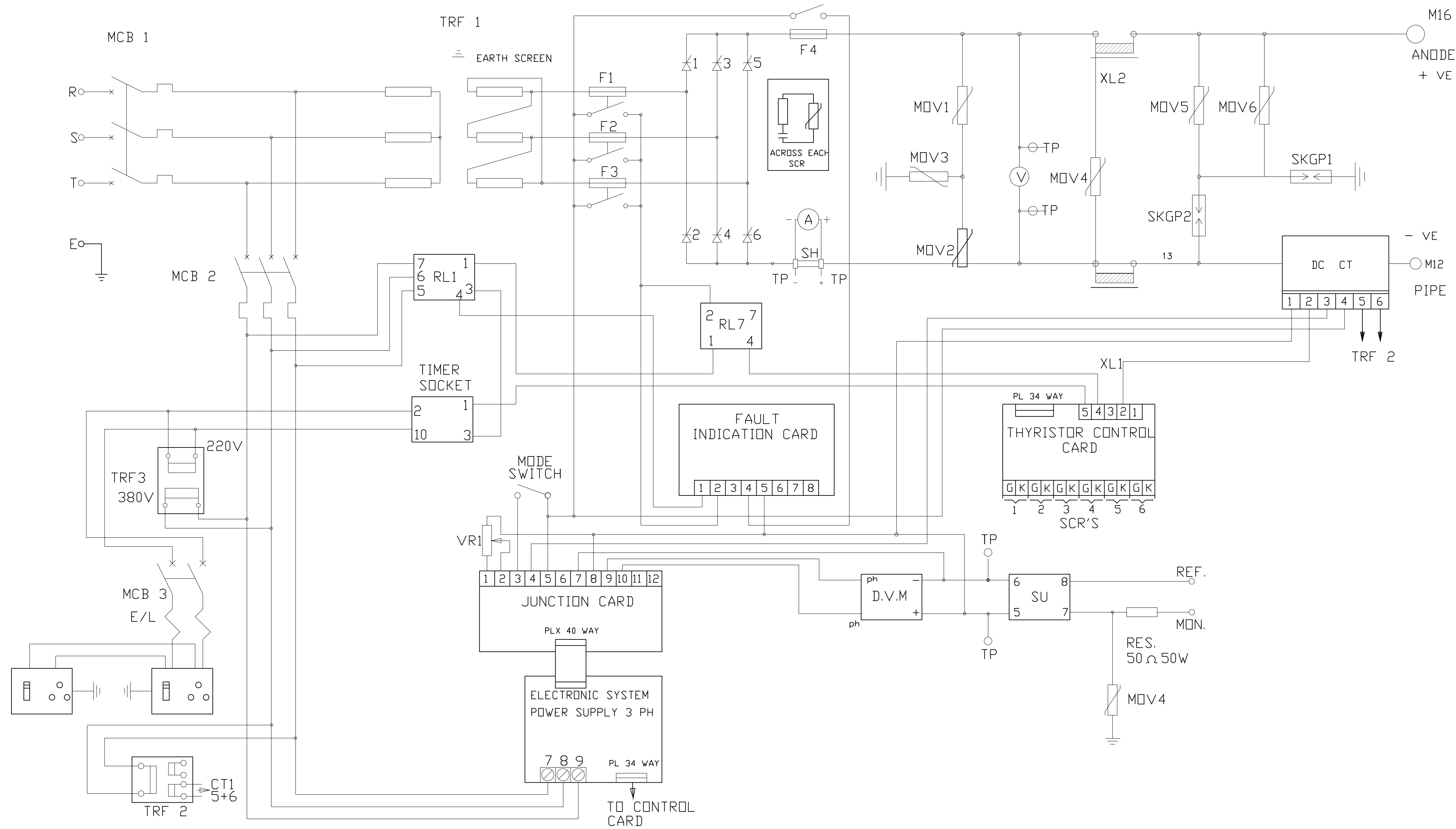
Joburg
a world class African city

SCALE

[illegible]

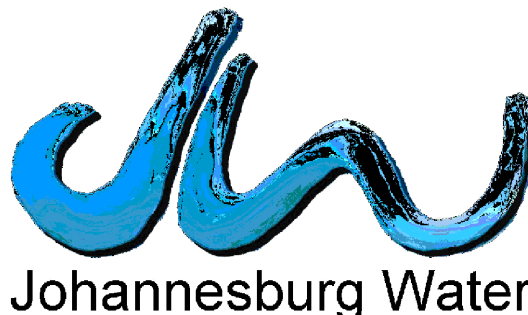
UR	STD	—	A
PROJECT No.	DISCIPLINARY		REV.
A1	SHEET	1	OF 1
ORIGINAL PAGE SIZE			
FILE No.			

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.



TYPICAL ELECTRICAL SCHEMATIC OF THREE PHASE THYRISTOR CONTROLLED TRANSFORMER RECTIFIER UNIT
SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Municipality:  a world class African city	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL ELECTRICAL SCHEMATIC OF THREE PHASE THYRISTOR CONTROLLED TRANSFORMER RECTIFIER UNIT	SCALE N.T.S.	AMENDMENTS					DRAWING No: JW-23-001-D018	
	DRAWN	---	Date:						REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No: A1 SHEET 1 OF 1 ORIGINAL PAGE SIZE FILE No:	
	CHECKED	---	Date:						A	ISSUED FOR INFORMATION					
	APPROVED BY:	---	Date:												
	SIGNATURE:	---	Date:												
	SIGNATURE:	---	ECSA REG. No:												

This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.



UR	STD	-	A
PROJECT No.	DISCIPLINARY		REV.
A1	1	OF	1
ORIGINAL PAGE SIZE			
FILE No.			

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. MINIMUM EXTERNAL DIMENSIONS OF (w) 2040mm x (h) 2260mm x (d) 2040mm WITH 90 mm WALL THICKNESS.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.3.3 AND 5.3.3.
3. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

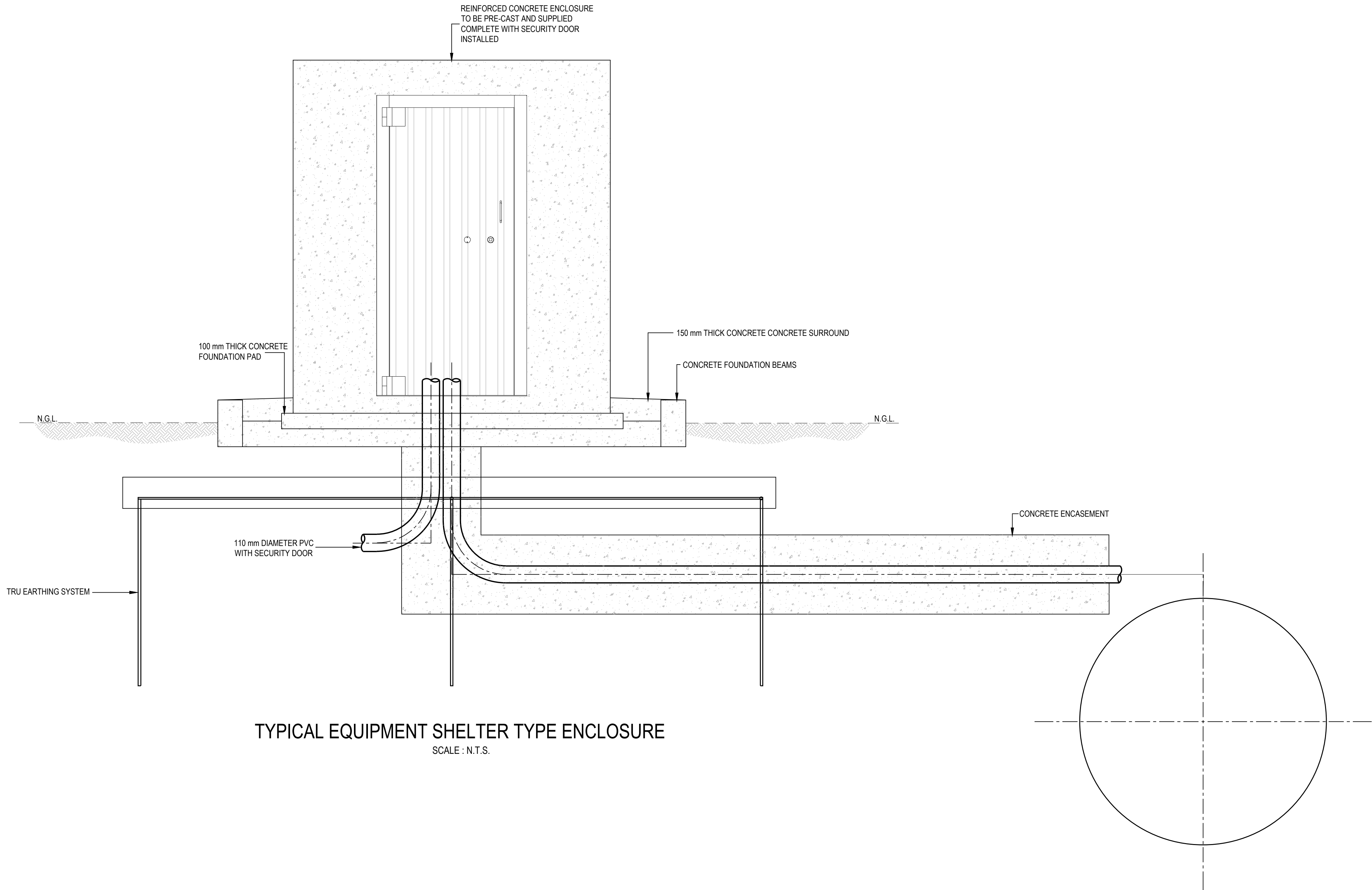
ELECTRICITY

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

ELECTRODE AND COUPON

1. BAGGED DIMENSIONS APPROXIMATELY 460mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .

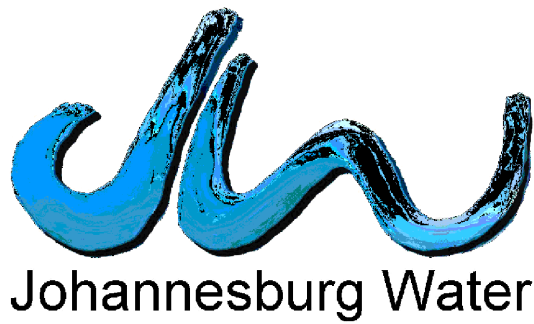


TYPICAL EQUIPMENT SHELTER TYPE ENCLOSURE
SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:
DRAWN	---	Date:
CHECKED	---	Date:
APPROVED BY:	---	Date:
SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL EQUIPMENT SHELTER TYPE ENCLOSURE

SCALE

AMENDMENTS

N.T.S.

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR INFORMATION			

DRAWING No:

JW-23-001-D03

PROJECT No:

ORIGINAL PAGE SIZE

FILE No:

DISCIPLINARY

SHEET

OF

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

CATHODIC PROTECTION

- GRADIENT CONTROL MAT TO BE 100mm x 100mm x 4mm HOT DIP GALVANIZED WELD MESH.
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.10, 5.1.4 & 5.2.2

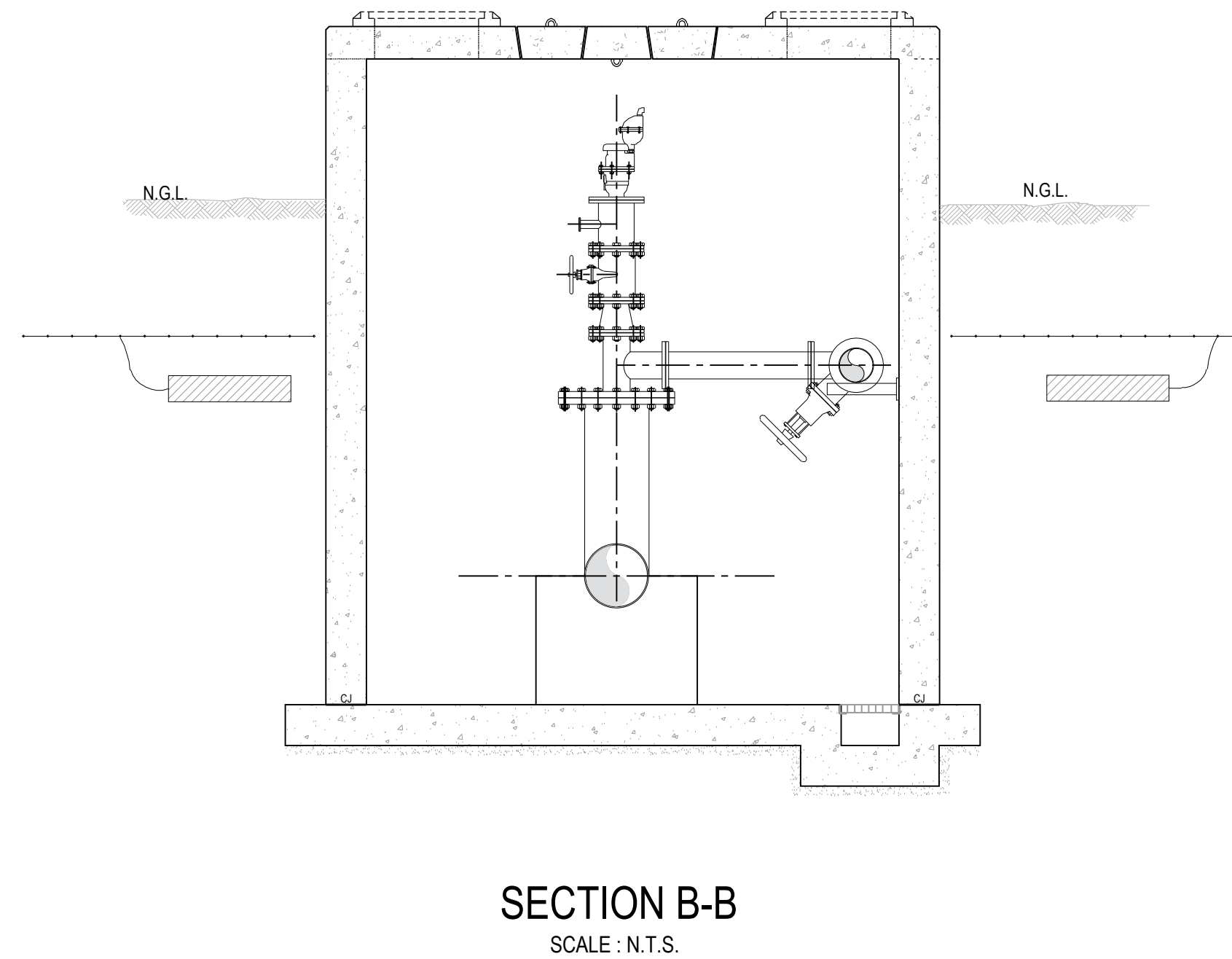
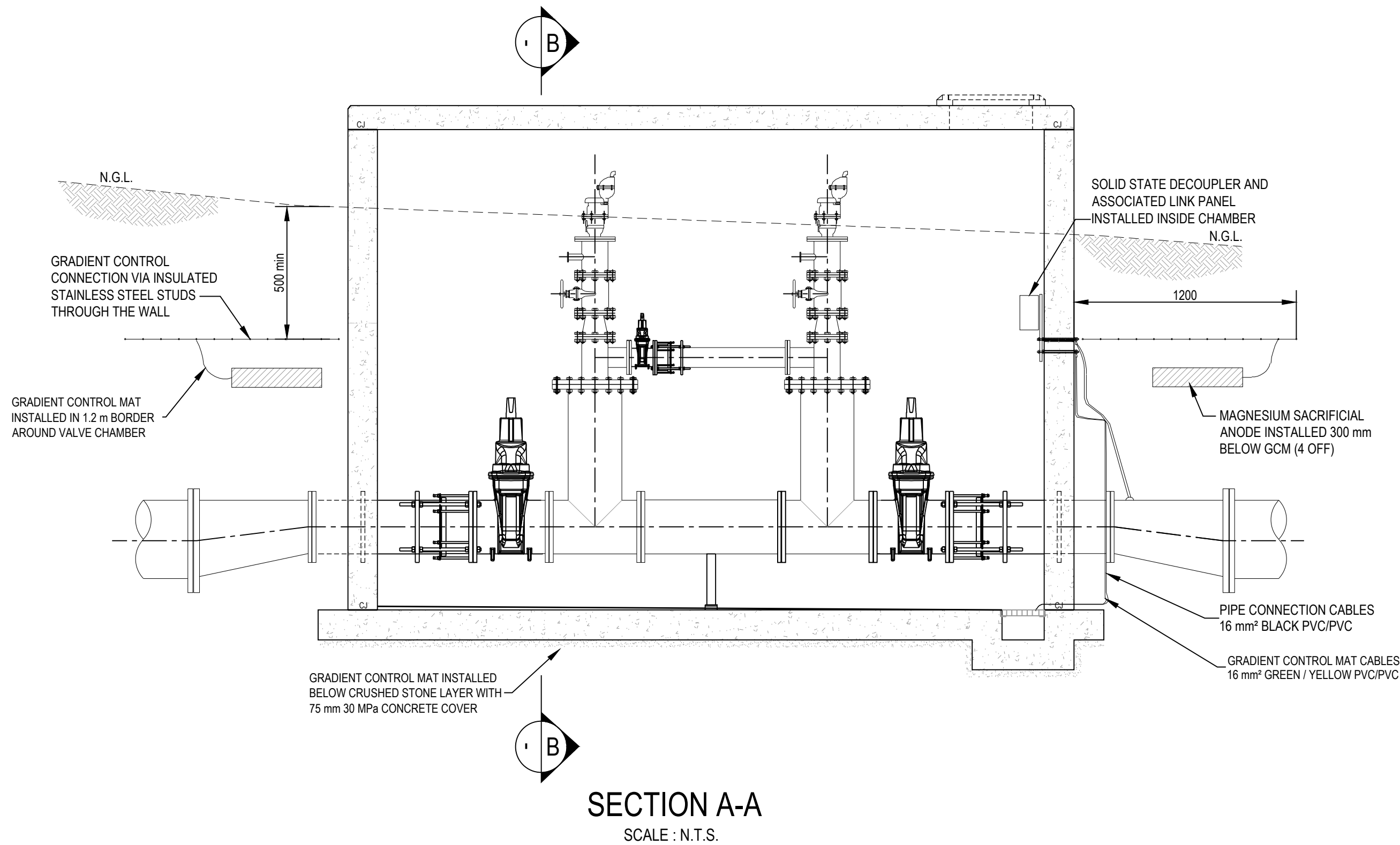
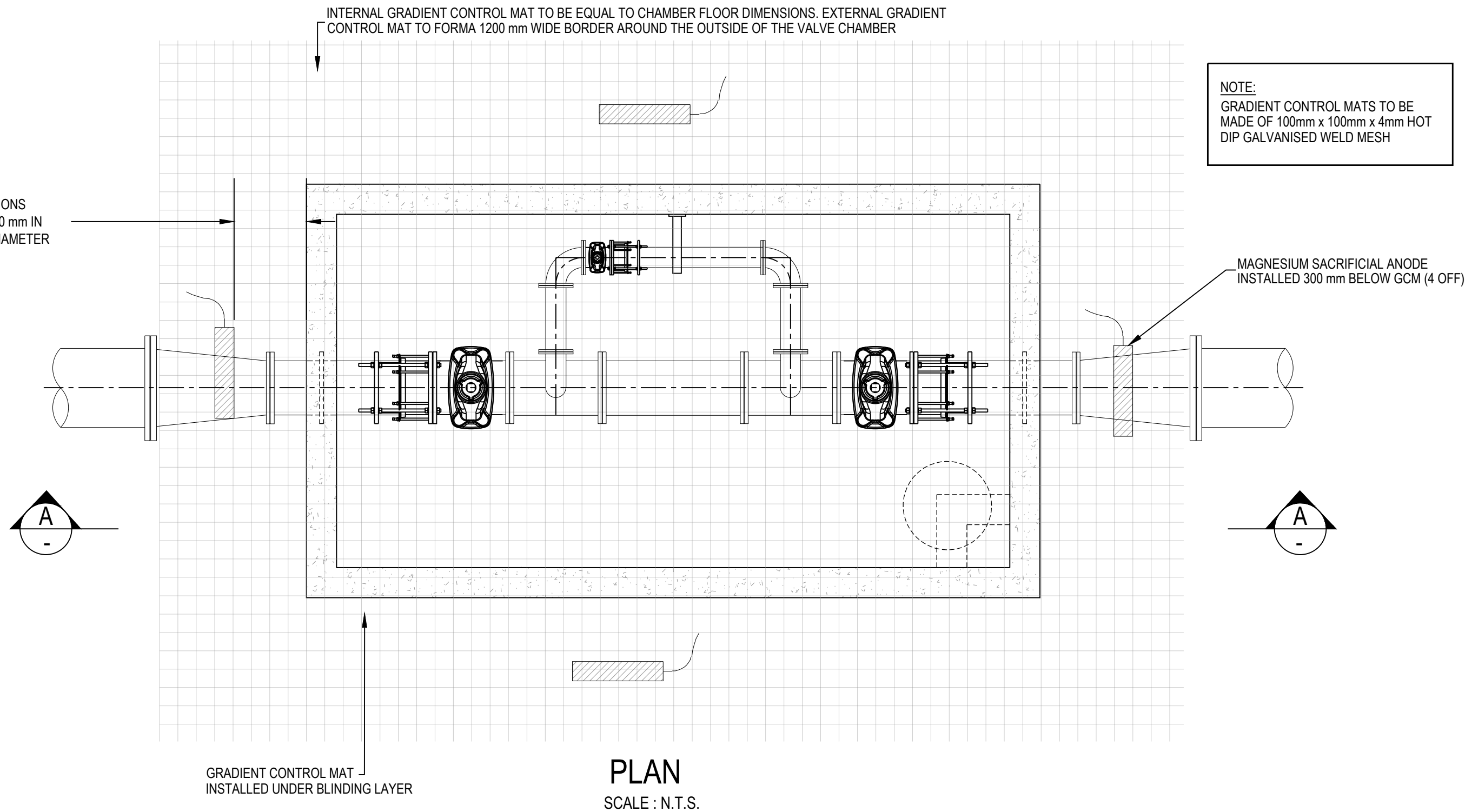
ELECTRICITY

- SOLID STATE DECOUPLING DEVICE TO BE OF THE VOLTAGE LIMITING DEVICE (VLD) TYPE.
- SEE ESKOM GUIDELINE ON THE ELECTRICAL COORDINATION OF PIPELINES AND POWER LINES GL240-66418968 Rev 1. SECTION B4.

SACRIFICIAL ANODE

- SACRIFICIAL ANODES TO BE 14.5KG HIGH POTENTIAL MAGNESIUM PACKAGED IN COTTON BAG WITH CHEMICAL BACKFILL (70% GYPSUM, 25% BENTONITE AND 5% SODIUM SULPHATE, IN A FINELY POWDERED FORM)
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.8.

ISSUED FOR INFORMATION



TYPICAL GRADIENT CONTROL MAT AT LARGE CHAMBER

SCALE : N.T.S.

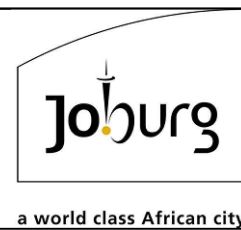
CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:
	DRAWN	---	Date:
	CHECKED	---	Date:
	APPROVED BY:	---	Date:
	SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:

Project description:



a world class African city

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL GRADIENT CONTROL MAT AT LARGE CHAMBER

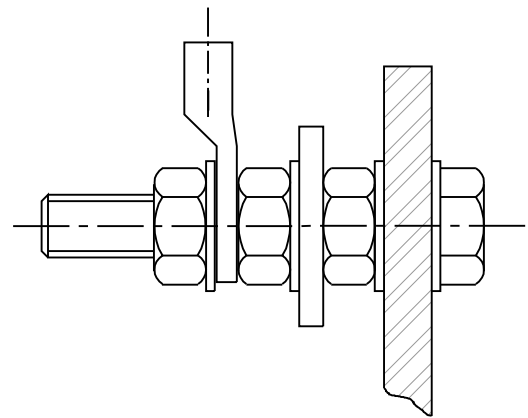
SCALE	AMENDMENTS						DRAWING No:	JW-23-001-D09
	REV	DESCRIPTION	DATE	BY	APV			
N.T.S.	A	ISSUED FOR INFORMATION					UR PROJECT No: A1 ORIGINAL PAGE SIZE FILE No:	STD DISCIPLINARY 1 SHEET OF 1

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

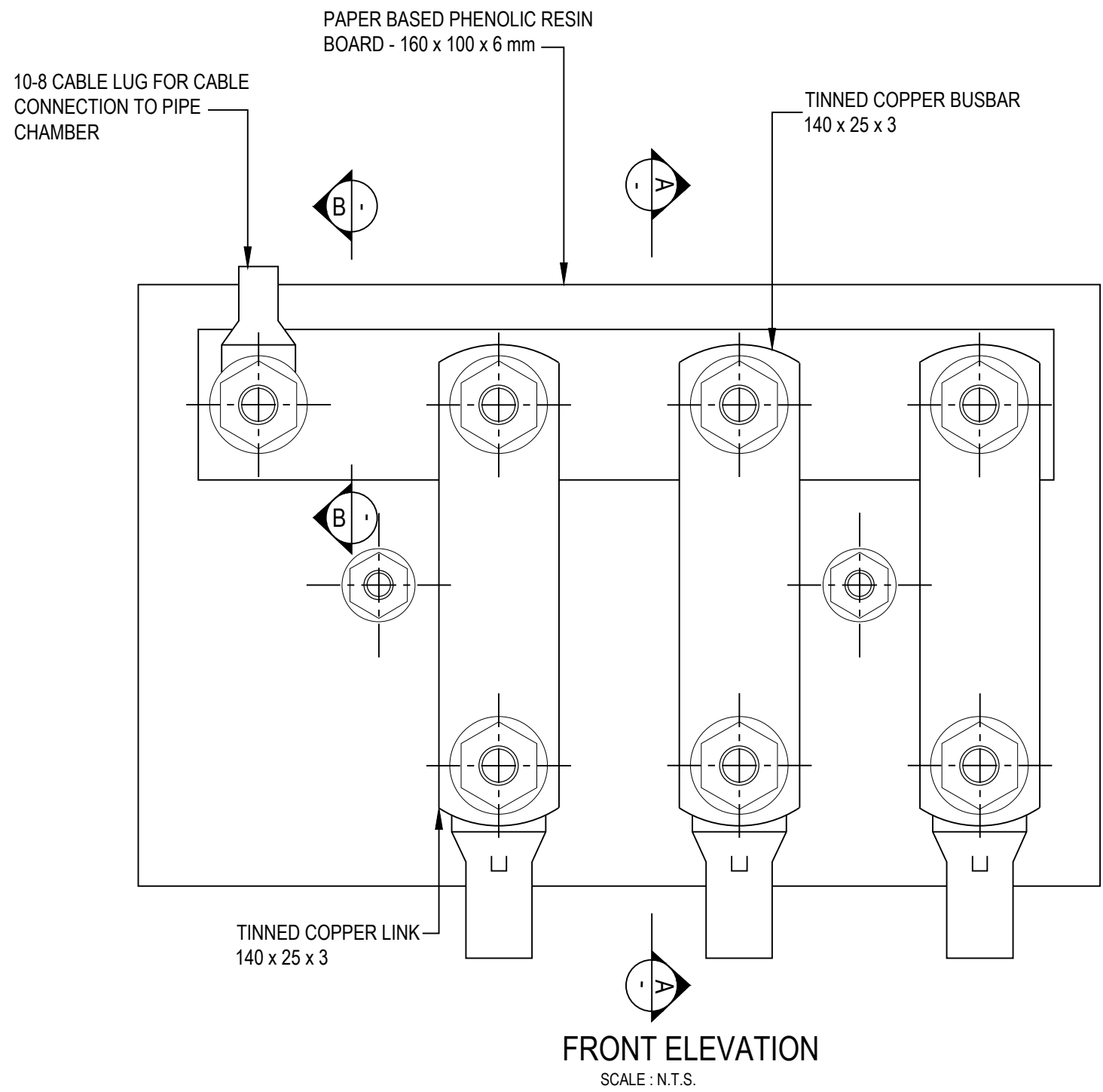
GENERAL NOTES

ELECTRICITY

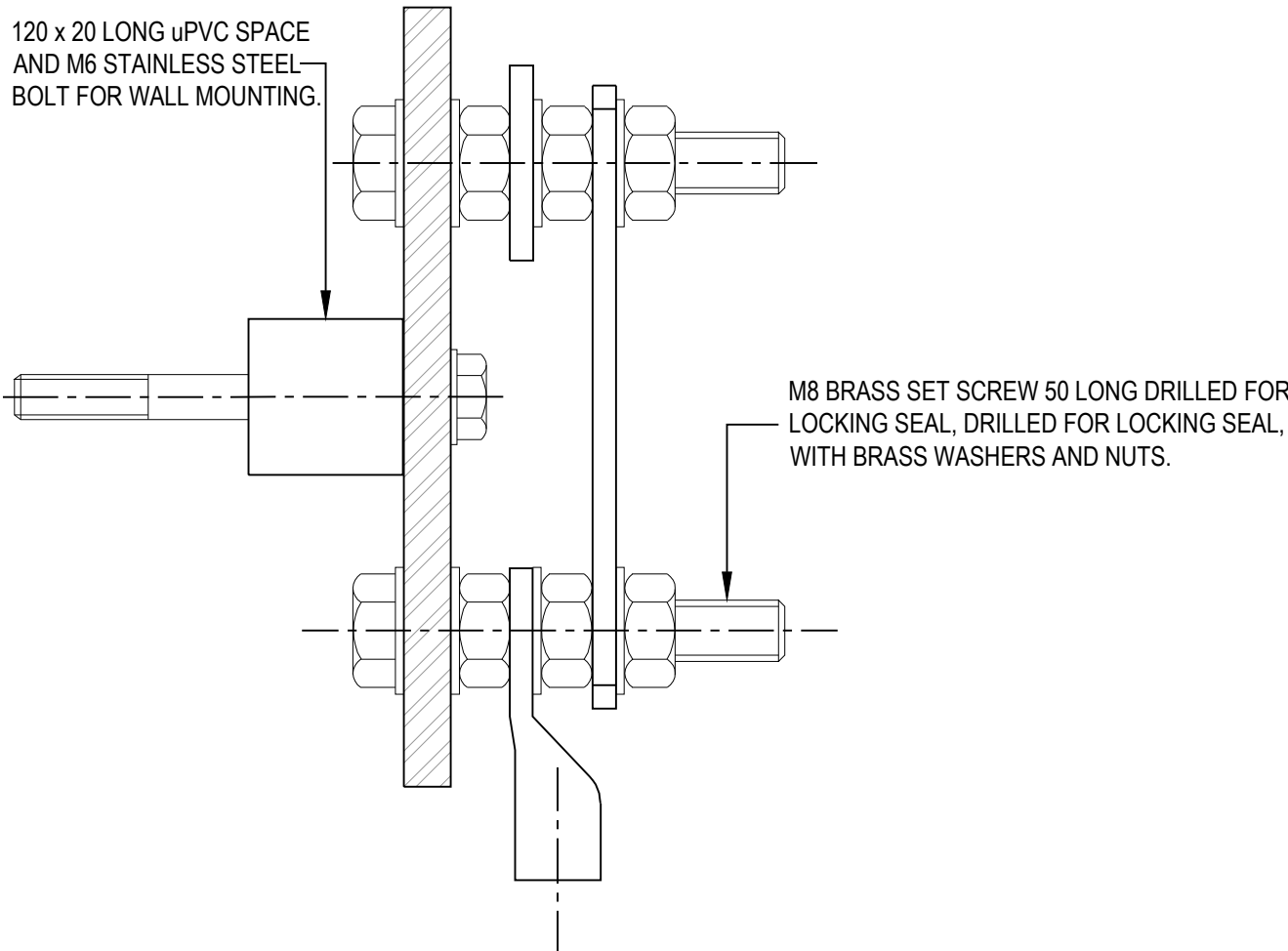
- SOLID STATE DECOUPLING DEVICE TO BE OF THE VOLTAGE LIMITING DEVICE (VLD) TYPE.
- SEE ESKOM GUIDELINE ON THE ELECTRICAL COORDINATION OF PIPELINES AND POWER LINES GL240-66418968 Rev 1. SECTION B4.
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.6, 4.13, 4.14, 4.15 AND 5.5.1.2.1.



SECTION B-B
SCALE : N.T.S.



FRONT ELEVATION
SCALE : N.T.S.



SECTION A-A
SCALE : N.T.S.

TYPICAL LINK PANEL
SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL LINK PANEL	 a world class African city	SCALE	AMENDMENTS					DRAWING No: JW-23-001-D013	
	DRAWN	---	Date:					REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No. A1 ORIGINAL PAGE SIZE FILE No.		

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

REINFORCED CONCRETE ENCLOSURE TO BE PRE-CAST

1. MINIMUM EXTERNAL DIMENSIONS OF (w) 2040mm x (h) 2260mm x (d) 2040mm WITH 90 mm WALL THICKNESS.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.3.3 AND 5.3.3.
3. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

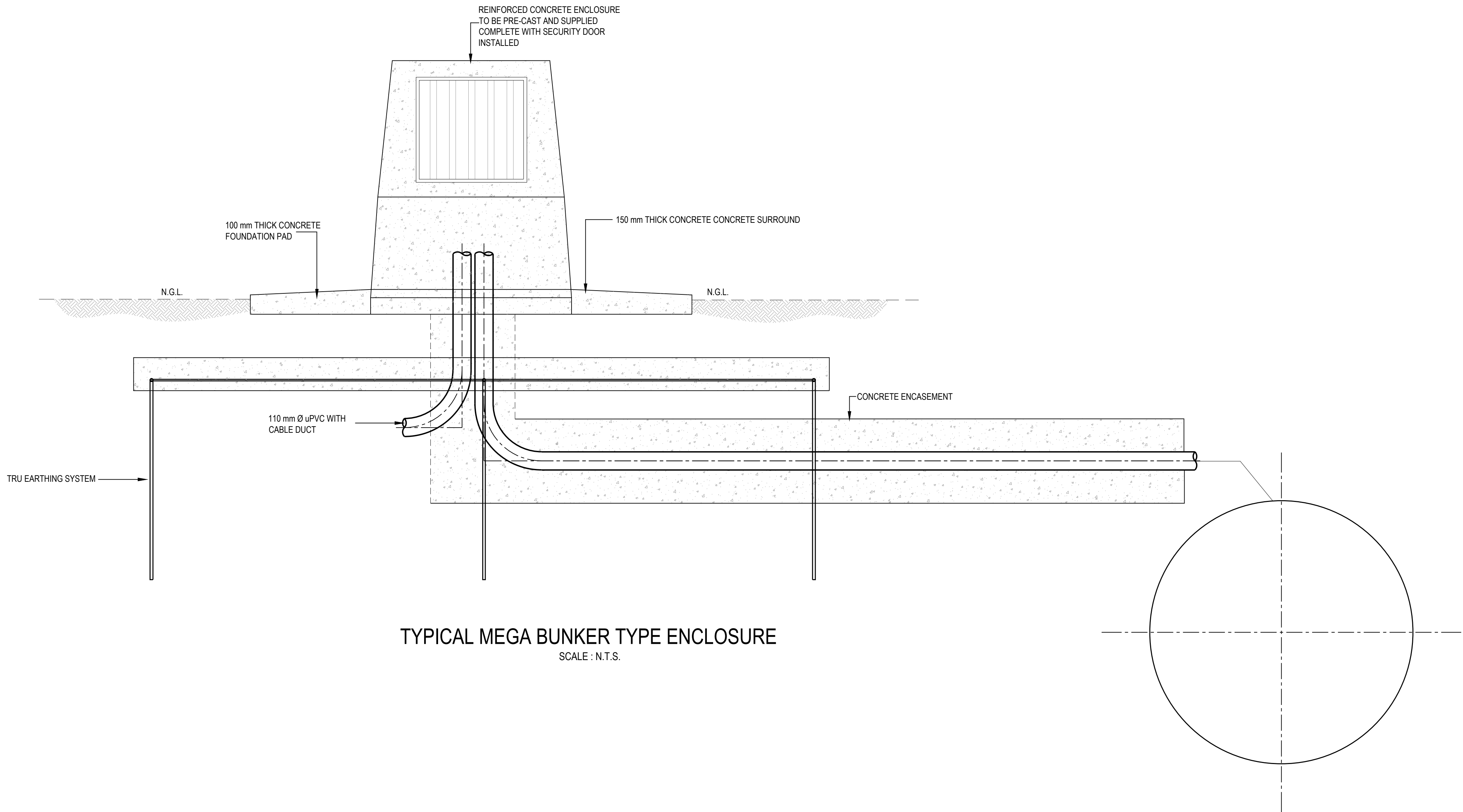
ELECTRICITY

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENT AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

ELECTRODE AND COUPON

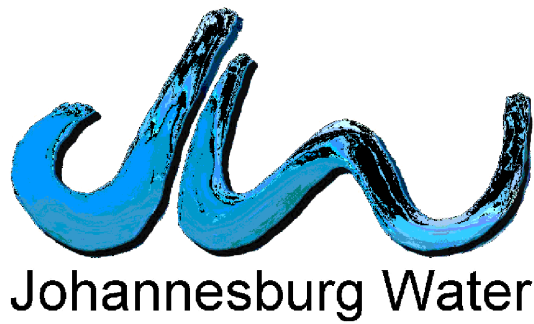
1. BAGGED DIMENSIONS APPROXIMATELY 460mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .



ISSUED FOR INFORMATION

CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:	
	SIGNATURE:		
DRAWN	---	Date:	
	SIGNATURE:		
CHECKED	---	Date:	
	SIGNATURE:		
APPROVED BY:	---	Date:	
	SIGNATURE:	ECSA REG. No:	



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL MEGA BUNKER TYPE ENCLOSURE

SCALE

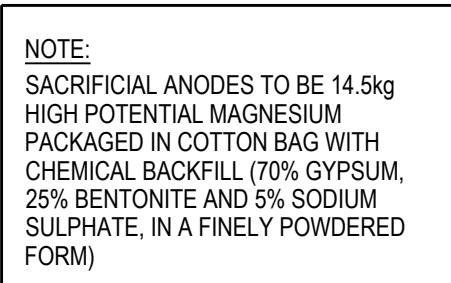
AMENDMENTS

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR INFORMATION			

AS SHOWN

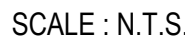
DRAWING No: JW-23-001-D04

UR	STD	-	A
PROJECT No:	DISCIPLINARY	REV.	
A1	SHEET	1	OF 1
ORIGINAL PAGE SIZE			
FILE No:			



--	--	--	--	--	--

This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.

[illegible]

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date:
	SIGNATURE:		
	DRAWN	---	Date:
	SIGNATURE:		
	CHECKED	---	Date:
	SIGNATURE:		
APPROVED BY:	---	Date:	
	SIGNATURE:		
	ECSA REG. No:		



Johannesburg Water

JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



a world class African city

Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL TRU ENCLOSURE PERIMETER SECURITY CONCRETE FOUNDATION DETAIL

SCALE	AMENDMENTS					DRAWING No:	JW-23-001-D023
N.T.S.	REV	DESCRIPTION	DATE	BY	APV	UR PROJECT No. A1 ORIGINAL PAGE SIZE FILE No. STD DISCIPLINARY SHEET 1 OF 1	
	A	ISSUED FOR INFORMATION					



SCALE : N.T.S.

1. BAGGED DIMENSIONS APPROXIMATELY 460mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .

UR	STD - A	
PROJECT No.	DISCIPLINARY	REV.
A1	SHEET 1 OF 1	
ORIGINAL PAGE SIZE		
FILE No.		

This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.

Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

REINFORCED CONCRETE ENCLOSURE TO BE
PRE-CAST

1. MINIMUM DIMENSIONS TO BE 315mm OUTER DIAMETER BY 1500mm IN LENGTH. INTERNAL CAVITY TO BE 150mm DEEP.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.5.2, 4.5.3 AND 5.3.4.

CABLE SIZES AND LENGTHS

1. LENGTHS TO BE QUANTIFIED AS PER SITE REQUIREMENTS AND REFERENCED ACCORDINGLY IN THE BILL OF QUANTITIES.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.13 & 4.14, 4.15, 5.2.1, 5.12, 5.13 AND 5.14.

1. BAGGED DIMENSIONS APPROXIMATELY 460mm IN LENGTH BY 200 mm DIAMETER.
2. SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.4 AND 5.4 .



DRAWING No: JW-23-001-D014

CONSULTING ENGINEERS CAPEX - ENGINEERING SERVICE UNIT TURBINE HALL - 3RD FLOOR 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113	DESIGNED	---	Date: _____	 Johannesburg Water	JOHANNESBURG WATER SOC Ltd TURBINE HALL 65 NTEMI PILISO STREET NEWTOWN JOHANNESBURG 2113 TEL: +27 (0)11 688 1400 FAX: +27(0)11 688-1528	Municipality: _____  a world class African city	Project description: ENGINEERING SERVICE UNIT - STANDARD DETAIL TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION TYPICAL uPVC TYPE MONITORING ENCLOSURE	SCALE N.T.S.	AMENDMENTS					DRAWING No: JW-23-001-D014 UR PROJECT No. _____ A1 ORIGINAL PAGE SIZE _____ FILE No. _____ STD - A DISCIPLINARY _____ SHEET 1 OF 1 REV. _____
	SIGNATURE: _____													
	DRAWN	---	Date: _____											
	SIGNATURE: _____													
	CHECKED	---	Date: _____											
	SIGNATURE: _____													
APPROVED BY: _____	---	Date: _____												
SIGNATURE: _____					ECSA REG. No: _____									

COPYRIGHT:
This document and all the information thereon remains the property of Johannesburg Water SOC Ltd and may not be copied, reproduced or transmitted in part or in full without the written consent of Johannesburg Water SOC Ltd. This document should not be relied on nor used in circumstances other than those for which it was originally prepared and for which Johannesburg Water SOC Ltd was commissioned, as defined on this drawing. Refer to the contract for full terms and conditions.
Johannesburg Water SOC Ltd shall not be liable for the consequences of using this document other than for the purpose for which it was commissioned. Any user and any other person using or relying on the document for such other purpose will by such use or reliance be taken to confirm his agreement to indemnify Johannesburg Water SOC Ltd for all loss or damage results there from.

GENERAL NOTES

CATHODIC PROTECTION

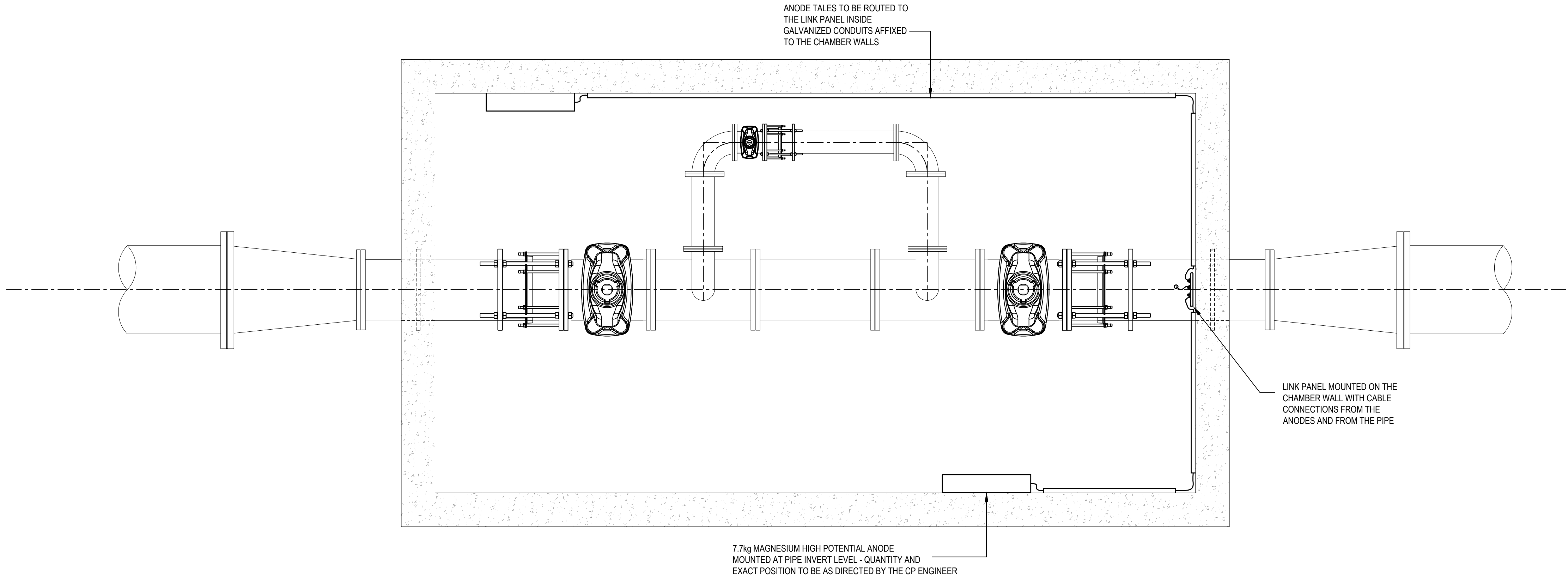
- GRADIENT CONTROL MAT TO BE 100mm x 100mm x 4mm HOT DIP GALVANIZED WELD MESH.
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.10, 5.1.4 & 5.2.2

ELECTRICITY

- SOLID STATE DECOUPLING DEVICE TO BE OF THE VOLTAGE LIMITING DEVICE (VLD) TYPE.
- SEE ESKOM GUIDELINE ON THE ELECTRICAL COORDINATION OF PIPELINES AND POWER LINES GL240-66418968 Rev 1, SECTION B4.

SACRIFICIAL ANODE

- SACRIFICIAL ANODES TO BE 14.5KG HIGH POTENTIAL MAGNESIUM PACKAGED IN COTTON BAG WITH CHEMICAL BACKFILL (70% GYPSUM, 25% BENTONITE AND 5% SODIUM SULPHATE, IN A FINELY POWDERED FORM)
- SEE JOHANNESBURG WATER CATHODIC PROTECTION STANDARD SPECIFICATION SECTIONS 4.8.



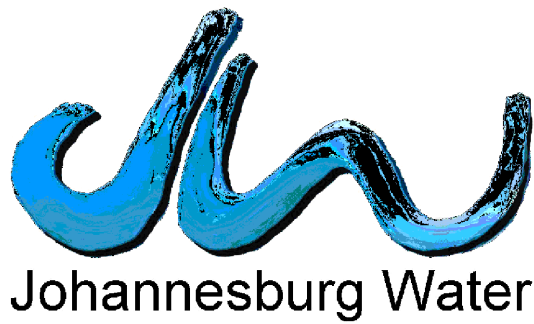
TYPICAL VALVE CHAMBER ANODE INSTALLATION

SCALE : N.T.S.

ISSUED FOR INFORMATION

CONSULTING ENGINEERS
CAPEX - ENGINEERING SERVICE UNIT
TURBINE HALL - 3RD FLOOR
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113

DESIGNED	---	Date:
DRAWN	---	Date:
CHECKED	---	Date:
APPROVED BY:	---	Date:
SIGNATURE:	---	ECSA REG. No:



JOHANNESBURG WATER SOC Ltd
TURBINE HALL
65 NTEMI PILISO STREET
NEWTOWN
JOHANNESBURG
2113
TEL: +27 (0)11 688 1400
FAX: +27(0)11 688-1528

Municipality:



Project description:

ENGINEERING SERVICE UNIT - STANDARD DETAIL
TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION
TYPICAL VALVE CHAMBER ANODE INSTALLATION

SCALE

AMENDMENTS

N.T.S.

REV	DESCRIPTION	DATE	BY	APV
A	ISSUED FOR INFORMATION			

DRAWING No:

JW-23-001-D010

UR	STD	A
PROJECT No:	DISCIPLINARY	REV.
A1	SHEET	1 OF 1
ORIGINAL PAGE SIZE		
FILE No:		

C4 PROJECT SPECIFICATIONS

A. GENERAL

PROJECT SPECIFICATIONS

A: GENERAL

PS1 CONSTRUCTION WORKS SPECIFICATIONS

PS1.1 APPLICABLE NATIONAL STANDARDS

For the purposes of this Contract, SABS 1200 or SANS 1200 Standardised Specifications applicable to this Contract is listed under B: STANDARDISED SPECIFICATIONS

As from 8 November 2002, all South African standards that were previously published by the South African Bureau of Standards with the prefix "SABS" have been re-designated as South African National Standards and will henceforth be published by Standards South Africa (a division of SABS) with the prefix "SANS" (see Government Notice No. 1373 of Government Gazette 24002).

Note that all standards in existence before 8 November 2002 may be referred to indefinitely, in any context, by either their "SABS" number or by their "SANS" number, both of which will be equally valid.

The prefix "PSA" indicates an amendment to SABS 1200 A General, "PSG" to SANS 1200G Concrete Works Structural, etc. The numbers following these prefixes are the relevant Clause numbers in the relevant SANS 1200 specification. These variations are included under section C3.6 of this document.

VARIATIONS AND ADDITIONS TO STANDARDISED SPECIFICATIONS

Variations and additions to the Standardised specifications are described under VARIATIONS AND ADDITIONS TO STANDARDISED SPECIFICATIONS.

PS1.2 OTHER APPLICABLE SANS STANDARDS

The following SANS specifications are also referred to in this document and the Contractor is advised to obtain them from Standards South Africa (a division of SABS) in Pretoria.

SANS 1921-1 (2004): Construction and Management Requirements for Works Contracts
Part 1: General Engineering and Construction Works

PS1.3 DISCREPANCIES BETWEEN DIFFERENT SECTIONS OF THE DOCUMENTATION

For the purpose of resolving ambiguities or inconsistencies after award of the tender, the authority of documents shall be:

- a) The General conditions of Contract for Construction Works (2015);
- b) Contract specific data;
- c) Variations to the General Conditions of Contract;
- d) Additional Conditions of Contract;
- e) The Contract Drawings.
- f) The Schedule of Quantities and Rates (the Bill of Quantities);
- g) Project Specifications;
- h) Particular Project Specifications;
- i) Standardized Specifications with variations, additions and omissions;

PS1.4 CERTIFICATE BY RECOGNISED BODIES

Wherever possible items and materials for construction of the Works shall comply with the relevant South African Bureau of Standards Specifications and with the British Standards where these are applicable in the absence of local standards.

The Contractor shall be responsible for the supply of all equipment, labour and materials for the Works.

PS1.5 EQUIPMENT, LABOUR AND MATERIALS SUPPLIED BY THE EMPLOYER

The Contractor shall be responsible for the supply of all equipment, labour and materials for the Works.

PS1.6 REQUIREMENTS FOR EQUIPMENT

All equipment and machinery shall be fit for purpose and able to perform the intended work safely and at the production tempos stated in the approved project plan. The Contractor is under obligation to have all lifting equipment as well as all machinery equipped with pressure vessels, regularly tested in terms of the OHS Act and Regulations.

PS1.7 EXISTING SERVICES

• TREATMENT OF EXISTING SERVICES

The contractor will be required to contact the relevant statutory undertakings, service providers or local authorities to ascertain the location of all services.

• DETECTION EQUIPMENT

No detection equipment is available to determine the depth of existing pipe work prior to the commencement of excavations.

• DAMAGE TO SERVICES

The contractor shall be liable for all costs incurred in the repair of any known service damaged by his works or machinery. An item has been included in the schedule of quantities in which the contractor is to include all costs that may occur as a result of any of the known services which may require relocation. Such costs are to include for

attendance by the service authority's personnel and plant, materials used for the relocation of the service, and possible delays in the construction of the works.

PS1.10 SITE ESTABLISHMENT

- **ADVERTISING RIGHTS**

No advertising by the Contractor will be allowed on site. All advertising rights will vest in the Employer.

- **NOTICE BOARDS**

The contractor will be responsible to supply and erect two Johannesburg Water notice boards at the entrance to the works and close to the main road passing by.

- **SOURCE OF WATER SUPPLY FOR DOMESTIC AND CONSTRUCTION PURPOSES**

The Contractor is responsible for any temporary connection required, whether on site or elsewhere and shall pay all installation and consumption charges. He shall also be responsible for transporting the water from the connection point to the point of use on the site. Johannesburg Water is the water supply authority in the area.

- **SOURCE OF POWER SUPPLY**

Application must be made to CITY POWER for a temporary power supply to the site. The Contractor will have to apply for a temporary connection for construction purposes, the cost of which will be for his account. All power used for construction purposes as well as the safe onsite distribution will be for the Contractor's account. The tender will be held to include for all such costs and charges.

- **CONTRACTOR'S CAMP AND DEPOT**

The contractor shall provide all his office accommodation and all associated facilities required for the adequate supervision, control and execution of the works. The contractor may use the site to establish his camp, offices and precast facilities subject to approval by the employer and the local municipal authority. However, should the contractor be required to move his camp during the contract period, the cost will be deemed to have been included in the tender rates. The contractor must not cut down or damage any trees or make any excavation without the written permission of the engineer.

The area occupied shall be neatly fenced off to denote its limit. The provision of security for the contractor's site establishment and activities for the duration of the contract shall be his own responsibility and no claims for additional security measures taken during the currency of the contract will be considered.

All buildings, latrines etc. shall be in accordance with the local authority and state health regulations, and shall be kept in a clean and sanitary condition to the satisfaction of the engineer. The contractor shall be responsible for the proper upkeep and control of the area for the duration of the contract and all structures and buildings shall be kept in good repair.

The contractor shall provide screened latrines as necessary for his employees, including local labour, the siting of which shall be to the satisfaction of the engineer. They shall be constructed and maintained by the contractor to the satisfaction of the engineer and in accordance with the requirements of government, provincial and/or local authority. All applicable fees and charges due under any health by-law or any or all of the above authorities shall be paid by the contractor.

Chemical toilets, or where possible, flush units shall be used and these shall be kept in a thoroughly clean and sanitary condition. Chemical toilets shall be serviced at least once a week. There is no municipal sewerage service available and flush units may only be used if connected to a regularly serviced conservancy tank. The effluent may only be discharged at a municipal waste water treatment plant.

A separate latrine shall be provided at the site camp for the sole use of the engineer and the engineer's representative and shall meet all of the requirements described above.

All these facilities shall be provided within 14 days of the engineer's instruction to commence with execution of the the works and the contractor shall strictly enforce their use.

On completion of the works and removal of the depot, the site shall be cleaned and restored to its natural condition immediately when it is vacated.

- **DISPOSAL OF REFUSE**

The contractor shall be responsible for disposal of refuse and waste generated by his staff on a daily basis. The site is to be kept clean, neat and tidy, to the employer's satisfaction. The contractor shall locate nearest solid waste disposal site at his own cost for the disposal of refuse. The permission of the waste site operator has to be obtained prior to any material being spoiled on this site. The contractor is responsible for all costs relating to disposal of material at any refuse site.

- **TELEPHONE**

This facility will be required and the Contractor is to make his own arrangements in this regard.

- **HOUSING FACILITIES**

The Contractor will not be required to provide housing facilities for the Engineer's staff. Accommodation for the Contractor's employees will not be permitted on site.

- **PARKING FACILITIES**

A single 3m x 6m shade cloth covered parking bay will be required for the Engineer.

- **TEMPORARY OFFICES**

Site facilities in the form of a 20m² office with a window, lockable door and air-conditioning will be required for the Engineer. It must be provided with two 15A double plug points, 2X1.2m fluorescent lights, plan table 1.8mX1m, desk with 3 drawers and 2 chairs. Survey assistants and the use of survey and measuring equipment will be required.

- **LABORATORIES AND STORES**

None will be required by the Engineer.

- **SITE USAGE**
- **WORKS AREA**

The Contractor shall ensure that all the works, temporary works, plant, equipment, stores and personnel are confined to the limits of the site as defined in Clause 2,0.1.29 in the General Conditions of Contract, and no encroachment onto private property shall be permitted without the owner's written consent.

Should any encroachment or damage occur, the Contractor shall immediately remove such encroachment or repair such damage, at his own expense, to the satisfaction of the Engineer and/or the Employer.

- **WORKING SPACE**

In certain cases working space may be limited. The method of construction in these restricted areas will depend largely on the Contractor's plant. However, the Contractor must note that measurement and payment will be according to the specified cross-sections and dimensions irrespective of the method used to achieve these cross-sections and dimensions, and that the rates and prices tendered shall be deemed to include full compensation for any difficulty encountered while working in poor ground conditions and that no extra payment will be made, nor will any claim for payment due to these difficulties be considered.

The Contractor will not be allowed to transgress onto adjacent private property without the express approval of both the land owner and the Engineer. All adjoining properties will be inspected by the Contractor, the Engineer and the respective land owners, prior to the commencement of the Works.

- **PERMITS AND WAYLEAVES**

The Contractor is to ensure that all wayleaves required by the applicable authorities are in place, prior to the commencement of any construction. The contractor shall further liaise with

the local authorities and local property owners to arrange for access to the site and all temporary works.

It is the Contractor's responsibility to obtain final permit and wayleave approval according to applicable procedures and specifications. Permits and wayleave associated costs shall be deemed to have been included in the scheduled rates for excavation and location of existing services.

PS2 MANAGEMENT

PS2.1 APPLICABLE SANS 1921 STANDARDS

The following SANS 1921 Construction and management requirements for works contracts, standards and associated specification data are applicable:

SANS 1921-1 General Engineering and Construction Works

The specification data applicable to the SANS 1921 standards mentioned above are as follows:

Clause	Specification Data
ESSENTIAL DATA	
4.2.1	The responsibility strategy assigned to the Contractor for the Works is A
4.3	The planning, programme and method statements are to comply with the following: 1. Programme is to show all activities, critical path, approval of documentation after commencement, all long lead items, allow for normal rainfall and Public Holidays. 2. The Contractor is to programme the Works to show all shutdowns for tie-in and temporary bypass purposes and advance warning requirements. 3. The Method Statement provided for the temporary bypass is indicative only of the estimated scope of work. The Contractor is to refine the logic sequencing and task durations to minimise the possible shut down periods.
4.4	The Contractor will be solely responsible for the production of work that complies with the Specifications to the satisfaction of the Engineer. To this end, it will be the full responsibility of the Contractor to institute an appropriate Quality Assurance (QA) system on site. The Contractor shall ensure that efficient supervisory staff, the required transport, instruments, equipment and tools are available to control the quality of his own workmanship in accordance with his QA-system. His attention is drawn to the fact that it is not the duty of the Engineer or the Engineer's Representative to act as foreman or surveyor.
4.12.2	The samples of materials that the Contractor is to provide and deliver to the employer are as stated in the Standard and Project Specifications:
4.12.2	The fabrication drawings that the Contractor is to provide and deliver to the Employer are as stated in the Standard and Project Specifications:
4.14.3	The office accommodation, equipment, accommodation for site meetings and other facilities for use by the Employer and his Agents are: 1) One office as per SABS 1200 A or AB, whichever is referred to in this document, if such facilities are specified in the Bill of Quantities. 2) Safety helmets, gumboots and other necessary safety equipment for the sole use of the Employer and his Agents. 3) Survey equipment as per PSAB 4.2 4) No testing laboratory is required on site for use by the Engineer.
4.14.5	The Employer and his Agents will make use of toilet facilities to be provided by the Contractor for the Engineer as specified in C3.4.6.5 above.

Clause	Specification Data
4.17.3	The Contractor will be required to confirm the locations and status of all services irrespective of whether they are shown on the drawings or not. Where public services must be interrupted on account of the Works, it shall be the Contractor's responsibility, in conjunction with the appropriate Authority to ensure that all users affected by the interruption are given due and sufficient notice of the date, time and duration of the interruption.
4.17.4	The requirements for detection apparatus are: NIL
4.17.7	Existing services, which are damaged by the Contractor, shall be repaired by the service provider and all costs of the repair shall be borne by the Contractor.
4.18	The additional Health and Safety requirements of the Employer are as specified in the Health and Safety Specification included in the Particular Specifications.
VARIATIONS	
4.2,0 o)	Record drawings are to be provided electronically on CD in AutoCAD format and at least one copy is to be provided on paper.
ADDITIONAL CLAUSES	
4.6 (e)	The Contractor is to ensure that storm water runoff or any groundwater seepage is controlled in terms of the approved Environmental Management Plan.
4.9.5	It will be necessary for the Contractor to liaise closely with the Local Authorities, the Local Community and the Engineer's Representative regarding any disruption of the water or electrical supply or access as a result of his construction activities. The Contractor shall advise all parties in writing at least seven (7) days in advance of any such operation, the time for which the supply will be disrupted and the area that will be affected. Disruption of water supplies to any area shall not exceed eight (8) hours in duration. It is recommended that connections to existing pipework be undertaken during weekends or during night time when the water consumption is at a minimum. The Contractor is to ensure that access is maintained at all times to all parts of the Works. The Contractor is to programme the Works to show all shutdowns for tie-in purposes and advance warning requirements.
4.9.6	The provision of security for the Contractor's site establishment, plant and personnel is the sole responsibility of the Contractor and no claims for payment for additional security measures taken during the currency

Clause	Specification Data
	of the Contract will be entertained.
4.17.8	The Contractor shall so carry out all his operations as not to encroach on, or interfere with, trespass on, or damage adjoining land, buildings, properties, road structures, pipelines, places and things, in the vicinity of the Works, without the written approval of the Engineer.

PS2.3 STANDARD: SANS 1921-6

Clause	Specification Data
ADDITIONAL DATA	
4.2.1 a)	A qualified service provider is one that appears on the list of recommended service providers, which is available from all regional offices of the Department of Public Works.

PS2.4 MANAGEMENT MEETINGS

The Contractor and such other persons as may be nominated by the Engineer shall be required to attend monthly site meetings, the date and place for which will be set by the Engineer in consultation with the Employer and Contractor.

PS2.5 Reports AND forms

The Contractor is expected to submit forms relating to plant, rainfall readings, labour, safety statistics, etc. to the Engineer during the monthly site meetings.

Templates of these forms are available electronically and may be requested from the Engineer.

PS2.6 CONTRACTOR'S SITE AGENT

The Contractor shall appoint a suitably qualified and competent Site Agent who shall be on site on a full time basis and at all times when work is being performed, for the full duration of the Contract.

PS2.7 DAILY RECORDS

The Contractor is to provide a Site Diary, which is to be kept on Site, for the purpose of keeping daily records in respect of Work performed on the site, including interruptions w.r.t. plant, labour and materials. Record keeping is to be augmented with date stamped digital photographs.

PS2.8 RECORDING OF WEATHER

The Contractor is to supply and install an accurate rain gauge of modern design and all other necessary equipment within the site camp area, in a position to be confirmed by the Engineer on Site in order to accurately measure rainfall. This area shall be fenced off from the rest of the site camp area and shall have a single pedestrian gate with lock. The Contractor's Site Agent and the Engineer's Representative will have access to the key and will be allowed access to the rain gauge. Rainfall records read at this rain gauge will be kept by the Contractor's Site Agent and the Engineer's Representative. The Engineer's Representative shall use these rainfall records in order to confirm days on which rainfall results in a stoppage of work, critical to the completion of the whole of the Works. The Contractor's tendered rates shall be deemed to include for the supply and installation of the rain gauge, other related equipment, fencing, gate, lock, key, etc.

PS2.9 ABNORMAL RAINFALL

If during the time for completion of the works or any extension thereof abnormal rainfall or wet conditions shall occur then an extension of time in accordance with clause 5.12.2 hereof shall be granted by the Employer calculated in accordance with the formula given below for each calendar month or part thereof.

$$V = (Nw - Nn) + ((Rw - Rn)/X)$$

V	Extension of time in calendar days in respect of the calendar month under consideration.
Nw	Actual number of days during the calendar month on which a rainfall of Y mm or more has been recorded.
Nn	Average number of days, as derived from existing rainfall records, on which a rainfall of Y mm or more has been recorded for the calendar month.
Rw	Actual rainfall in mm recorded for the calendar month under consideration.
Rn	Average rainfall in mm for the calendar month as derived from existing rainfall records.

For purposes of the contract Nn, Rn, X and Y shall have those values assigned to them in the Appendix and/or the Specification.

The total extension of time shall be the algebraic sum of all monthly totals for the period under consideration, but if the total is negative the time for completion shall not be reduced due to subnormal rainfall. Extensions of time for part of a month to be calculated using pro rata values of Nn and Rn.

This formula does not take account of flood damage that could cause further or concurrent delays and will be treated separately as far as extension of time is concerned.

The factor (Nw-Nn) shall be considered to represent a fair allowance for variations from the average number of days during which rainfall exceeds Y mm. The factor (Rw-Rn)/X shall be considered to represent a fair allowance for variations from the average in the number of days during which the rainfall did not exceed Y mm but wet conditions prevented or disrupted work.

The following average rainfall figures are applicable:

INFORMATION SOURCE: South African Weather Service
Pretoria, Tel.: 082 233 8484

Y = 10 mm/24 hour day
X = 20 mm

Table 5.1: Statistical rainfall

STATISTICAL INFORMATION: JOHANNESBURG BOTANICAL GARDENS: 1985-2006		
Month	RAINFALL	
	Nn = Actual number of days during the calendar months in which a rainfall of more than Y-mm has been received	Rn Average monthly rainfall
January	4.1	116.4
February	3.6	121.3
March	2.6	96.0
April	2.0	30.4
May	0.5	15.2
June	0.1	5.9
July	0.0	1.5
August	0.2	8.7
September	0.3	13.2
October	2.0	66.0
November	3.0	84.5
December	3.8	105.4
TOTAL	21.3	664.6

The Contractor shall be permitted to take his own rainfall measurements on site subject to the Engineer's approval, but access to the measuring gauge(s) shall be under the Engineer's control. The Contractor is to provide and install all the necessary equipment for accurately measuring the rainfall as well as to provide, erect and maintain a security fence plus gate, padlock and keys at each measuring station, all at his own cost

PS2.10 Spoil Material

No indiscriminate spoiling of material will be allowed. All surplus or unsuitable material shall be spoiled in designated areas as directed by the Engineer on Site, or beyond the boundaries of the Site, as designated by the Contractor at his risk, or at a regional spoil site. The first priority throughout the duration of the Contract shall be to satisfy any fill requirements under this Contract. Material will only be spoiled with the written approval of the Engineer.

PS2.11 Co-operation with Other Service Agents and Public Authorities

Other contractors and public authorities may be working on the site during the course of this Contract. The Contractor shall co-operate with these workmen and provide reasonable access to the site to enable them to carry out their work.

If the Contractor is obstructed in any way by such work he shall notify the Engineer within 24 hours, otherwise no claim for delay shall be considered.

PS2.12 Courtesy

In all dealings with the public, the Contractor shall bear in mind their right to enjoy the use of the roads and services and access to their properties. The Employer desires to interfere as little as possible with these rights. At all points of contact with the public, the Contractor and its staff are requested to handle discussions and disputes with deliberate courtesy and understanding.

PS2.13 Accommodation of traffic

Where the Works affect the safety or operation of vehicular and/or pedestrian traffic, the Contractor shall provide, erect and maintain such traffic signs, barricades, warning lights and personnel as are necessary or ordered.

The Contractor shall abide by the guidelines and procedures set out in the Safety at Roadworks in Urban Areas site manual as published by the Department of Transport for the National Transport Commission, 1984.

The Contractor may, with the approval of the Engineer, make arrangements with the occupiers of the affected roads, properties and businesses to close off a portion of a street, road, footpath or entrance temporarily, provided the Contractor duly notifies the occupiers of the intended closure and its probable duration and shall, as punctually as possible, re-open the route at the prescribed time.

The road shall be made safe and re-opened to traffic overnight. Any such closure shall be made by arrangement between the Contractor and the occupiers and shall not absolve the Contractor from his obligations under the Contract to provide access at all times. Barricades, traffic signs and drums shall be provided by the Contractor to suit the specific conditions.

It must be noted that services such as telephone and power poles, stay poles and stay wires and fences may be located within close proximity and within the site. The Contractor will be required to take due care for the protection thereof and will be liable for any damage to these services.

PS2.14 Finishing and Tidying and Site Maintenance

During the progress of the Work and upon its completion, the Site of the Works shall be kept and left in a clean and orderly condition. The Contractor shall at all times store materials and equipment for which he is responsible in an orderly manner, and shall keep the site free from debris and obstruction.

Progressive and systematic finishing and tidying will form an essential part of this Contract. On no account must spoil, rubble, materials, equipment or unfinished operations be allowed to accumulate in such a manner as to unnecessarily impede the activities of others, and in the event of this occurring, the Employer shall have the right to withhold payment for as long as may be necessary in respect of the relevant Works in the areas(s) concerned without thereby prejudicing the rights of others to institute claims against the Contractor on the grounds of unnecessary obstruction.

Finishing and tidying must not be deferred to the end of the Contract. The Works will not be certified as complete, until the whole of the Works including all finishing and tidying, has been fully completed to the satisfaction of the Engineer.

All finishing and tidying shall be carried out to the best advantage of the project as a whole and in the closest co-operation with other Contractors.

PS2.15 Length of Trenches

Unless otherwise permitted in writing by the Engineer, not more than 50m of trench in any one place and not more than 50m of trench in total within the project area shall be opened in advance of pipe laying operations. No trench may be left open over the builders' holidays or on extended long weekends. The cost of backfilling any trenches before the shut-down period and the re-opening thereof after the shut-down period shall be for the Contractor's account.

PS2.16 EXCAVATION OF TRENCHES

Machine and hand excavation will be permitted after proving of services.

All requirements of the OSH Act shall be complied with, with respect to shoring for both excavation methods.

PS2.17 Testing and Quality Control

The Contractor shall engage the services of a testing laboratory, to be approved by the Engineer, to carry out all testing of materials and quality control testing as described in the relevant Standardised Specifications, as well as other testing as may be elsewhere described.

No separate payment will be made for such testing by an approved laboratory and the costs thereof will be deemed to be included in the Contractor's tendered rates for the various items of work requiring testing in accordance with the specifications.

The results of all such tests including CBR's, UCS's, densities and all other tests as are described in the specifications and at not less than the prescribed frequency, shall be immediately communicated to the Engineer in writing.

The results of such tests by an approved laboratory shall not be regarded as final and binding upon the Engineer, who shall base his decisions relating to the acceptability of the quality of the work, not only on the basis of such tests by an approved laboratory, but also on the results of any such additional tests as he may decide to carry out. The cost of such acceptable control testing shall be to the Employer's account, with the exception of tests on sections which fail to meet the requirements, where the costs of such tests shall be borne by the Contractor.

PS2.18 Opening Up and Closing Down of Borrow Pits

Only registered local borrow pits may be used.

PS2.19 Survey Beacons

The Contractor shall protect all survey beacons during construction of the Works. The site has been provided with beacons and the Contractor takes full responsibility for the preservation of these beacons.

All beacons must be identified and whitewashed before the construction activities commence and the Contractor shall confirm in writing to the Engineer before commencement of construction that all beacons have been proven.

Any beacons not proven must be listed and the list submitted to the Engineer for referral to the Land Surveyor before commencement of any construction activities. The Land Surveyor will verify the existence of these beacons and if proven to exist, will be entitled to recover from the Contractor, if necessary through deductions from the Contractor's payment certificates, any costs incurred. Beacons the Land Surveyor is not able to prove will be reinstated by him in conjunction with the Contractor's construction activities.

Any beacons that have been disturbed or removed during construction will be replaced at the Contractor's expense. When construction has been completed, the Contractor shall identify and whitewash all beacons for inspection by the Engineer before a certificate of practical completion will be issued.

Where proper execution of the Works necessitates the removal of beacons, the Contractor shall give notice to this effect to the Engineer, allowing sufficient time for the listing and relocation, removal or reference marking of such beacons. On completion of construction, before the Practical Completion Certificate is issued, the Contractor shall expose and whitewash the reference pegs relating to the beacons that were listed and removed or disturbed and arrange for the beacons to be replaced by a Land Surveyor. Only when the Engineer is satisfied that the removal of beacons had been imperative, will payment for the replacement of beacons not be at the Contractor's expense.

PS2.20 Occupational Health and Safety Act No. 85 of 1993 and Regulations

The Contractor shall comply with the requirements of the Occupational Health and Safety Act and the Regulations as well as the safety specification bound into this document. The Contractor shall enter into an agreement with the Employer in the form set out elsewhere in this document.

B. STANDARD SPECIFICATIONS

The standard specifications on which this contract is based are the South African Bureau of Standard Standardized Specifications for Civil Engineering Construction SABS 1200, also now referred to as SANS 1200.

Although not bound in, nor issued with this document, the following sections of the Standardized Specifications of SANS 1200 shall form part of this document.

SABS 1200	A	General
SABS 1200	AB	Engineer's office
SABS 1200	C	Site Clearance
SABS 1200	DA	Earthworks (small works)
SABS 1200	DB	Earthworks (pipe trenches)
SABS 1200	DM	Earthworks (roads, subgrade)
SABS 1200	G	Concrete (structural)
SABS 1200	HA	Structural steelwork (small works)
SABS 1200	HC	Corrosion protection of structural steelwork
SABS 1200	L	Medium pressure pipeline
SABS 1200	LB	Bedding (pipes)
SABS 1200	LD	Sewers
SABS 1200	LE	Stormwater drainage
SABS 1200	ME	Subbase
SABS 1200	MF	Base
SABS 1200	MJ	Segmented paving
SABS 1200	MK	Kerbing and channeling

The following SANS specifications are also referred to in this document and the Contractor is advised to obtain them from Standards South Africa (a division of SABS) in Pretoria.

SANS 1921 – 1 (2004): Construction and Management Requirements for Works
Contracts Part 1: General Engineering and Construction Works

C. VARIATIONS AND ADDITIONS TO THE STANDARDIZED SPECIFICATIONS AND PARTICULAR ADDITIONAL SPECIFICATIONS

The following variations and additions to the SABS 1200 Standardized Specifications apply to this Tender. An amendment to SABS 1200 is indicated by the prefix "PS". The letters and numbers following these prefixes respectively indicate the relevant specification and clause in SABS 1200 to which it applies.

PSA GENERAL (SABS 1200A - 1986)

PSA 3 MATERIALS

PSA 3.1 QUALITY

Add the following:

All material used in the Works shall be new and no second or previously used material shall be allowed. All material shall, where such mark has been awarded for a specific type of material, bear the SABS mark. Alternatively, the Contractor shall furnish the Engineer with Certificates of Compliance of materials, which bear the official mark of the appropriate standard.

Add the following sub clauses:

PSA 3.3 SUPPLY OF MATERIALS

The contractor will be responsible to supply all the materials necessary for the proper execution of the works. The contractor shall also be fully responsible for quality of materials used and/or installed.

The quantities of material set out in the Schedule of Quantities were determined with the best intention of providing the most accurate amounts as possible from the calculations, design drawings and documentation. These quantities must be considered as approximate quantities only and the Contractor must verify the Quantities from site measurements prior to ordering the material. No liability will be attached to the Employer or his representatives in respect of materials ordered incorrectly from the amounts or the specifications as stated in the Schedule of Quantities.

PSA 5 CONSTRUCTION

PSA 5.1 SURVEY

Add the following:

The contractor must note that a limited amount of survey control points have been established. The Contractor will be required to verify the accuracy of such and shall be held responsible for any errors in the setting out of the works which may arise from the usage of this survey control.

PSA 5.2 WATCHING, BARRICATING, LIGHTING AND TRAFFIC CROSSING

Add the following:

TEMPORARY TRAFFIC SIGNS

The Contractor shall provide, erect and maintain on the site and at such positions on the approaches to the site all traffic signs necessary for the direction and control of traffic.

The details of all such signs, which shall conform to the current Road Traffic Ordinance and the departmental publication entitled "Safety in Road Construction", must be approved by the Engineer before erection.

The signs shall be reflectorised or adequate; illuminated at night in a manner approved by the Engineer and kept clean and legible at all times. The Contractor shall reposition, cover or remove signs as required during the progress of the works.

PSA 6.2 DEGREE OF ACCURACY (SUB CLAUSE 6.2)

Degree of accuracy II will apply to all work on this project, except on the tower columns, beams and tank wall where a degree of accuracy I will apply.

PSA 7 TESTING (SUB CLAUSE 7)

The onus rests on the Contractor to produce work, which conforms in quality and accuracy of the detail to the requirements of the Specifications and Drawings and the Contractor must at his own expense, institute a quality control system and will provide experienced Engineers, foremen, surveyors, material technicians and other technical staff, together with all the instruments and equipment, to ensure adequate supervision and positive control on works.

The cost of all the supervision and process control, including testing, so carried out by the Contractor, shall be deemed to be included in the rates rendered for the related items of work.

The Contractor's attention is drawn to the provisions of the various sections of the Specifications regarding the minimum frequency of the testing that will be required for process control. The Contractor shall at his own discretion increase the frequency where necessary to ensure adequate control.

The Contractor shall submit to the Engineer the results of all relevant tests, measurements and levels indicating compliance with the specifications on completion of every part of the work for examination.

Should the results of any of these tests fall below the required standards as specified in the specifications, the cost of any additional tests required by the Engineer will be to the account of the Contractor.

PSA 7.2 LABORATORY (SUB CLAUSE 5.2)

A laboratory for the use of the Engineer's representative is not required on site. A commercial laboratory approved by the Engineer and appointed by the Contractor shall do all acceptance control tests required in terms of the Contract. All tests must be done according to the tests prescribed in the SABS 1200 under the relevant sections.

PSA 8 MEASUREMENT AND PAYMENT

PSA 8.2.2 TIME RELATED ITEMS

Add the following:

An extension of time granted will not necessarily or automatically entitle the Contractor to additional payments of time related items. Additional payments for specific time related items after the granting of an extension of time must be motivated and substantiated by the Contractor and shall be subject to approval by the Engineer.

PSAB ENGINEER'S OFFICE (SABS 1200AB)

PSAB 3.1 NAMEBOARDS

The nameboards shall be according to Joburg Water's standard nameboard detail. No other name boards other than stated above shall be allowed. On completion of the works, the Contractor shall obliterate all particulars on the name board and remove the board from the site, prior to the release of retention money.

PSAB 3.2 OFFICE BUILDING

The Contractor shall provide and furnish an office for exclusive use by the Engineer and his representative, as well as a dedicated toilet for use by the Engineer's staff, as described in SABS 1200 AB clause 3.2

In addition to the standard requirements:

- a) The location of the office unit shall be selected in consultation with the Employer's Agent.
- b) The Employer's Agent must approve all internal furniture.
- c) Carport's shall be provided and shall cover not less than 24 m², with the ground surface consisting of a layer of crushed gravel (no larger than 9 mm) to combat dust and mud. The carport shall be easily accessible, and be such that cars are protected from direct sunlight all times of day, and against inclement weather.
- d) Electrical power from the local authority that is adequate for operating a computer, an air conditioning unit, a heater and a refrigerator.
- e) The Contractor shall, in addition to his facilities, further provide at the site camp a meeting room for the Employer's Agent. The meeting room shall have adequate seating and table to hold site and other meetings, for 15 people.

PSAB 4 EQUIPMENT

PSAB 4.1 Telephone

Add the following:

A telephone will not be required for the sole use of the Employer's Agent. However, the Contractor shall be responsible for the payment of calls related to the contract made by the Employer's Agent's Representative, on his own mobile phone, during the course of the contract.

Add the following:

PSAB 4.2 Computer Facilities

The Contractor shall, for the duration of the Contract, provide the computer equipment complete with printer, telephone connection and internet connection (ADSL or 4G) together with the software specified hereunder, for the exclusive use of the Employer's Agent and his staff:

- a) 1 computer
- b) 1 printer
- c) 1 Scanner

The computers shall comply with the following minimum specifications:

- ☐ Intel Core i3 3.30Ghz CPU
- ☐ 4Gb ddr3 memory module
- ☐ 500Gb hard drive
- ☐ Midi tower case + 550w power supply
- ☐ Dvd/Rw drive - internal
- ☐ Usb keyboard
- ☐ Usb optical mouse
- ☐ 18.5" or 19" Led/Lcd wide monitor
- ☐ Internet connection (ADSL or 4G)

Printers shall, unless otherwise approved by the Employer's Agent, be Hewlett-Packard Desk Jet printers or equivalent compatible. Printer to be able to scan, and print both A4 and A3 documents, in monochrome and colour

All computer hardware shall be provided complete with the requisite connecting cables and all interfacing devices and software necessary for its efficient operation as an integral system.

The following software shall be properly installed on the computer, and the original license agreements and disks shall be provided to the Employer's Agent for safekeeping:

- ☐ MS Windows Latest Edition
- ☐ MS Office Home and Business Latest Edition
- ☐ MS Projects Latest Edition

All computer equipment provided shall be kept fully serviceable at all times by the Contractor. The Contractor shall have any defective equipment repaired or replaced at his own cost within 12 hours of notification by the Employer's Agent's staff.

The Contractor shall further provide at his own cost, all paper, ink cartridges and other consumables reasonably required by the Employer's Agent.

PSC SITE CLEARANCE (SABS 1200C)

PSC 1 SCOPE

Add the following:

"Where labour intensive construction methods are applied, the maximum boulder size for removal under this specification will be 50kg. Boulders between 50kg and 0.15 m³ (i.e. approx 450kg) will be deemed to be removable by other methods under this specification.

PSC 3 MATERIALS

PSC 3.1 DISPOSAL OF MATERIAL

Add the following:

“Materials arising from clearing and grubbing shall be disposed of as maybe ordered by the Engineer. Trees and stumps necessarily removed shall not be burnt unless authorised by the Engineer, but shall be cut and stacked at areas designated by the Engineer.

The Contractor shall locate and obtain his own dumping site for the disposal of material. The Contractor shall comply with the requirements of any by-law, statute, ordinance, regulation and local authority requirements. The Employer will not accept any responsibility or liability in this regard.

No overhaul will be payable on the disposal of material arising from “clearing and grubbing”.

PSC 5 CONSTRUCTION

Add the following:

“Where labour intensive methods are applied, the Contractor shall be expected to adhere to the following:

- Hand tools shall be utilized.
- The use of motorised vehicles (trucks, etc) will only be permitted in cases where the distance of the cleared material is to be transported further than 150m. Provided always that such material must be loaded and off-loaded by labour.
- The use of pneumatic hand held breaking equipment will be allowed to break down hard material to an acceptable size suitable for labour intensive construction methods”

PSC 5.1

Add the following:

“The areas to be cleared and grubbed will be indicated by the Engineer. Should a portion or the whole of the site have been cleared and grubbed by nature or by others prior to the start of construction, then no clearing and grubbing will be ordered or payment made with respect to the applicable portion of the site.

Where not specifically stated, pipeline routes shall be cleared to a distance of 1.5m on both sides of the pipeline centre line. Route markers or bench marks may not be disturbed by these actions”.

PSC 5.2.3 PRESERVATION OF TREES

Add the following:

“The penalty in respect of every individual tree and shrub designated as a tree or shrub to be preserved that is damaged or removed unnecessarily by the Contractor, shall be R1 000. Trees that fall within areas upon which the Works are to be constructed or within areas that the Contractor must occupy for the proper construction of the Works will not be designated for preservation.

PSD **EARTHWORKS (SABS 1200D)**

PSD 5 CONSTRUCTION

PSD 5.1.2 EXISTING SERVICES

Known existing services are shown on the Drawings. The Contractor shall, however, continually be on the lookout for the unknown services and he shall immediately notify the Engineer if such a service should be located.

If the existing services are not shown on the drawings but the existence thereof can be reasonably expected, the Contractor shall, in conjunction with all the relevant authorities, determine the exact depth and location of such services before the commencement of construction. After locating the exact position of services and the Contractor shall be liable for all costs and the subsequent costs arising from the damage thereof as a result of the contractor's activities. The Contractor must also indicate these services in the "As Built" drawings.

All existing services where new connections are proposed must be located and opened by the hand excavation for inspection by the Engineer before commencing trench excavation. Any costs or losses suffered by the Contractor as a result of not abiding by this specification will be for the Contractor's account.

5.2.3.2 BACKFILLING OF TRENCHES AND BACKFILLING OR FILLING AGAINST STRUCTURES

Add the following to D 5.2.3.2:

Excavated material which is suitable for backfilling shall be stockpiled whilst all other materials from excavations shall be disposed off site. Backfilling to structures and embankments shall comply with the requirements indicated on the drawings and shall be compacted to 93% and 95% modified AASHTO density respectively.

Contractors are to note that no overhaul of backfill material will be measured and backfill quantities will only be measured up to the pay lines as indicated on the drawings. The Contractor shall be responsible for backfilling any working space and excavation slopes, over breaking, battery etc, beyond the indicated pay lines.

No backfilling behind the reservoir will be allowed until the hydraulic test has been completed.

PSDB 5 CONSTRUCTION

PSDB 5.1 Precautions

PSDB 5.1.1 General

Add the following to this sub-clause:

The Contractor shall programme his activities in such a way that long sections of trenches do not lie open for undue periods of time, as this poses a safety risk. The pipes shall be laid as soon as possible after excavation of the trenches and the

trenches then backfilled. Under no circumstances will trenches be left open for more than 1 week.

The Contractor shall inform the Johannesburg Road Agency (JRA) at least 2 days in advance of the actual date on which he proposes to excavate in any road or footway.

PSDB 5.1.4 Existing services that intersect or adjoin trenches

Add the following to this sub-clause:

Where it is necessary for a pipeline to pass under existing drains, the Contractor shall carefully excavate and backfill around them. During the course of the work, the drains shall be adequately supported to the satisfaction of the Engineer. Any damage shall be reported without delay and shall be made good by the Contractor before backfilling.

PSDB 5.4 Excavation

Add the following to this sub-clause:

Where the pipe trench crosses surfaced roads the Contractor shall neatly cut four parallel grooves into and through the "black top" before excavating between the inside 2 grooves. The outside 2 grooves should be 100 from the inside ones. The cost of this operation, where not scheduled separately, will be deemed to have been included in the general rates for excavation.

PSDB 5.5 Trench Bottom

Add the following to this sub-clause:

In waterlogged conditions and/or where so instructed by the Engineer, a 100mm thick layer of 20mm to 6mm graded stone shall be laid under the pipes.

PSDB 5.6 Backfilling

PSDB 5.6.1 General

Add the following to this sub-clause:

Notwithstanding the requirements of sub-clauses PSDB 5.6.1 and 5.6.6, no pipe joint or pipe-fitting shall be covered by either the blanket or the backfill prior to the successful completion of the visual inspection and the pressure testing of the relevant section of the pipeline and without the written permission of the Engineer.

PSDB 5.6.2 Material for backfilling

Add the following to this sub-clause:

No backfilling may be done unless it is authorised by the Engineer. Trenches must be backfilled and compacted to 90% modified AASHTO to at least 300mm above the pipe soffit in layers of 150mm around and above the pipe and care should be exercised to prevent damage to the pipe. Subsequent layers may be compacted in 175mm layers. Except where backfill material is in the opinion of the Engineer moist enough, water must be added to facilitate compaction.

In the event of no suitable material being available around the pipe for backfilling the trench in question, the Contractor must obtain suitable material from other excavations, transport it to the site and remove the unsuitable material to an approved dumping site. If no suitable material is thus obtainable, the Contractor must sift the material obtained from the trench through a sieve with a 10mm mesh, but, if above mentioned procedure is not practical, the Engineer may instruct the Contractor to import suitable material from approved sources and the Contractor will be under obligation to remove the unsuitable material to a dumping site.

If any settlement occurs during the Construction Period or before the end of the defects liability period, the Contractor must rectify such settlement to the satisfaction of the Engineer.

After all the excavations and backfilling have been completed, the surplus material and all additional material must be removed from the site to the satisfaction of the Engineer.

PSDB 5.6.3 Disposal of soft excavation material

Add the following to this sub-clause:

Surplus material or unsuitable material which is not disposed of within the trench servitude shall, on the instruction of the Engineer, be disposed of at approved tipping sites to be located by the Contractor.

The prior approval of the Engineer must be obtained before surplus material may be deposited, spread and levelled at agreed sites within the area of the works.

PSDB 5.6.4 Disposal of intermediate and hard rock material

Add the following to this sub-clause:

Surplus intermediate and hard rock material from trench excavations shall, on the instruction of the Engineer, be disposed of at approved tipping sites to be located by the Contractor.

The prior approval of the Engineer must be obtained before surplus material may be deposited, spread and levelled at agreed sites within the area of the works.

PSDB 5.6.5 Deficiency of Backfill Material

Add the following to this sub-clause:

All haul distances shall be freehaul distances.

PSDB 5.7 Compaction

PSDB 5.7.2 Areas subject to traffic loads

Add the following to this sub-clause:

In areas subject to traffic loading and in constructed footways compaction shall be done as directed by the Engineer or JRA specifications.

PSG CONCRETE STRUCTURAL (SABS 1200 G)

PSG 2 INTERPRETATIONS

PSG 2.1 SUPPORTING SPECIFICATIONS

Add the following:

SABS 1491 Part 1	:	Ground granulated blast furnace slag (GGBS)
SABC 1491 Part 11	:	Pulverised Fly Ash (PFA)
SABC 1491 Part 111	:	Condensed Silica Fume (CSF)

PSG 3 MATERIALS

PSG 3.1 APPROVAL OF MATERIALS

Add the following:

If during the progress of the work, the contractor desires to use materials of proportions other than those originally approved, or if in the opinion of the Engineer or his representative, the materials from the sources originally approved change in characteristics, he shall provide evidence satisfactory to the Engineer that the new materials and/or new combination of materials will produce concrete meeting the requirements of the specification and will not bring about unacceptable changes in the appearance or other characteristics of the structure.

When any changes are made in terms of this sub clause, they shall be made at the contractor's expense, and no extra payment will be allowed by reason of such change.

PSG 3.2 CEMENT

PSG 3.2.1 APPLICABLE SPECIFICATIONS

Add the following:

Ground granulated blast furnace slag (GGBS) used on the Works shall be from a source to be approved by the Engineer and shall comply with the requirements of SABS 1491 Part 1, as amended.

Pulverised Fly Ash (PFA) used on the works shall be from a source to be approved by the Engineer and shall comply with the requirements of SABS 1491 Part 11, as amended.

Condensed Silica Fume (CSF) used on the Works shall be from a source to be approved by the Engineer and shall comply with the requirements of SABS 1491 Part 111, as amended.

Cement types to be used under certain specific conditions of environment or geographic location are given in Table 1 – “selection of cement type”. A minimum amount of 375 kg/m³ and a maximum amount of 450kg/m³ of cementitious material will be required in the concrete irrespective of the type of cement used.

Table 1 – Selection of cement type

Location of Structure	Temperature of concrete	Type of Cement
	< 20°C	CEM11 A – S 42.5 CEM11 B – S 42.5 CEM11 A – M42.5
	20°C – 30°C	CEM11 A – S 42.5 CEM11 B – S 42.5 CEM11 A – M42.5 CEM11 A – V (or W) 32.5 CEM11 B – V (or W) 32.5
	>30°C	CEM11 A – S 42.5* CEM11 B – S 42.5* CEM11 A – M42.5* CEM11 A – V (or W) 32.5 CEM11 B – V (or W) 32.5

PSG 3.2.3 STORAGE OF CEMENT

No cement shall be stored on the site for a longer period than 28 days. After this period the Engineer may call for tests to be carried out in accordance with SABS 471, 831 or 626 and if the cement complies it may be used. Lumpy cement, broken pockets and sweepings shall not be used. The cement sacks shall be closely stocked, not more than 12 sacks high, and shall not be stacked against the walls. The arrangements of stacking shall be such as to facilitate the cement being used in the same order in which it is received.

PSG 3.3 WATER

Add the following:

Water shall be obtained from the city water supply where possible and shall be taken from any other source only on the approval of the Engineer. Where there is reason to suspect the presence of harmful impurities, the Engineer may require the contractor to submit the results of approved tests.

PSG 3.4 AGGREGATES

PSG 3.4.1 APPLICABLE SPECIFICATION

Replace the entire contents of the clause with the following:

Grading of fine aggregate: The grading of fine aggregate must comply with the requirements of Table 2 – “Grading of fine aggregate”. It should be noted that it is unlikely that a single sand with this grading will be available in the region under the control of Johannesburg Water and that two or more sands will have to be blended.

Table 2 – Grading of fine aggregate

Sieve Size	Percentage Passing
4 750 µm	90 - 100
2 360 µm	75 - 100
1 180 µm	60 - 90
600 µm	40 - 60
300 µm	20 - 35
150 µm	5 - 12
75 µm	0 - 5
FM	2.03 – 3.00

Grading of coarse aggregate: Coarse aggregate in structural concrete will have a maximum nominal size of 26.5mm as specified in SABS 1083 with due cognisance of the spacing of the reinforcing bars.

Water demand of sand: Sand with a water requirement in excess of 200L /m³ when made up into concrete with the intended mix proportions (including admixtures, if any) will not be allowed.

PSG 3.5 ADMIXTURES

PSG3.5.1 APPROVAL OF ADMIXTURES REQUIRED

Add the following:

For waterproofing and durability of the concrete, Penetron Admix crystalline water proofing additive with tracing agent shall be used. Minimum dosage shall be of 0,8% by weight of cementitious content in the concrete mix and shall carry a 20 year warranty. Penetron shall be added and used strictly according to the manufacturer’s specifications.

Other admixtures in the design of concrete mixes to modify the properties of the plastic concrete, may only be used with the approval of the Engineer. The use of admixtures, which have a retarding effect on the rate of hydration of the cement, may not be used when the concrete temperatures are below 20° C. When the concrete temperature exceeds 30° C, the use of retarding admixtures will be mandatory with cements that have a strength class 42.5R or 42.5. Admixtures containing chlorides shall not be used.

PSG 4 PLANT

PSG 4.1 GENERAL

Add the following:

When considered necessary by the Engineer, stand-by equipment shall be available at short notice.

PSG 4.2 BATCHING PLANT

Add the following:

The site batching of concrete shall be carried out by mass batching only.

PSG 4.3 MIXING PLANT

PSG 4.3.1 GENERAL REQUIREMENTS FOR MIXING PLANT

Add the following:

When considered necessary by the Engineer, a spare mixer shall be held in readiness to run on 15 minutes notice in case of breakdown of the mixer.

PSG 4.5 FORMWORK

PSG 4.5.1 DESIGN

Add the following:

The design of the formwork and supports shall be the responsibility of the Contractor and shall be designed and detailed by a registered Professional Engineer, if required by the special conditions of contract, and submitted for approval by the Engineer. All joints shall be either horizontal or vertical. Chamfer strips shall be provided on all exposed edges.

The design of all proposed formwork shall be subject to the approval of the Engineer. Such approval shall in no way relieve the Contractor of his responsibility under the contract.

PSG 4.5.3 TIES

Add the following:

The ends of any embedded ties shall have cover equal to that required for reinforcement. The gap left from the end of the tie to the face of the concrete shall be effectively sealed on both sides of the structure to ensure water tightness.

PSG 5 CONSTRUCTION

PSG 5.1 REINFORCEMENT

PSG 5.2,0 BENDING

PSG 5.2,0.4 Add the following:

All welding of mild steel, where permitted, shall be in accordance with BS 5135.

PSG 5.1.2 FIXING

Add the following:

All reinforcement placed in structures within 5km of the sea should be washed with clean, fresh water after placement in the formwork and not longer than 24hrs prior to the casting of concrete.

The placing of bars on fresh layers of concrete, as work progresses will not be permitted. No concrete shall be placed until the Engineer or his representative has stated that he is satisfied that the reinforcement is correctly positioned as shown on the drawings.

PSG 5.1.3 COVER

Replace clause 5.1.3 with the following:

All concrete cover blocks used shall be of semi-spherical shape. The concrete cover blocks used shall have the same characteristic 28-day compressive strength as that specified for the respective structural concrete elements. The reinforcing tie wire used in the manufacture of the cover blocks shall be hot dip galvanised. A minimum cover of 30mm must be maintained between the reinforcing tie wire and the conical end of the block.

The minimum clear cover to concrete over all reinforcement shall be as indicated in the following Table 3 unless otherwise specified on the drawings. Correct cover shall be maintained by concrete spacers whose strength is not less than that of the concrete specified. Suitable plastic spacers are permitted if approved by the Engineer.

Type of Construction	Min Cover mm
1. Slabs and Walls	
a) Plastered and unplastered internal work	The greater of 20 or d
	40
b) Exposed to water pressure	40
c) External walls	The greater for 40 or d
2. Columns	
3. Beams	
	The greater of 40 or 2d
a) End cover beyond hooks	The greater of 40 or d
b) All other surfaces	
4. Piles	40
a) Precast piles and on faces poured against formwork	75
b) On unformed faces poured against ground	50

5. All structures in sea water or in marine atmosphere	40
6. Structures in contact with backfilling or corrosive atmosphere	50
7. Footings	75
a) Members cast on a blinding layer	
b) Members cast in contact with the ground	

Note: In the above table “d” refers to the largest reinforcing bar diameter.

PSG 5.5.16 BLINDING CONCRETE:

Binding concrete shall be measured per square metre and shall include for a steel trowel finish true to falls.

PSG 5.2 FORMWORK

The surface of the blinding layer, the floor, the internal upper surface of the all footings and the upper surface of the roof end the slabs over the valve chamber shall be finished in accordance with clause PSG 5.2.1 class 4 – steel Float Finish.

The internal surfaces of all walls, columns and the underside of the roof and all exposed surfaces shall be finished in accordance with clause PSG 5.2.1 class 3a – Smooth Finish.

All surfaces in contact with backfill material may be finished in accordance with clause PSG 5.2.1 class 1 – Ordinary Surface Finish.

PSG 5.2.1 CLASSIFICATION OF FINISHES

Replace the entire Clause with the following:

Surface finishes to formed concrete faces shall be classified as hereunder –

Class 1: ordinary finish;

Class 2: rubbed finish;

Class 3: off the form finishes;

- (a) Smooth finishes,
- (b) Board marked finishes,
- (c) Special patterned finishes.

Class 4: exposed aggregate finishes;

- (a) brushed en washed finishes,
- (b) Tooled finishes,
- (c) Sand blasted finish,
- (d) Aggregate transfer finishes.

Class 5: applied finishes:

- (a) Rendered finishes,
- (b) Painted finishes.

Class 1 – Ordinary Surface Finish

This is the finish left on a concrete surface after the removal of the forms and the filling of all holes left by shuttering bolts and the repairs of all defects. The surface shall be true and even, free from stone pockets, depressions and projections.

Class 2 – Rubbed Finish

Immediately after removal of the shuttering all defects shall be made good and the rubbed finish shall be applied within three days as follows:

Before starting this work the concrete shall be kept thoroughly saturated with water for a minimum period of 3 hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of the bolt holes and defects to set properly. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall consist of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all projections and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place for at least five days. The surface shall be smoothed by being rubbed lightly with a fine carborundum stone.

Class 3 – Off the Form Finishes

Off the form finishes require a very high standard in concrete quality, formwork and technique. The intention is that no after treatment other than treatment of bolt-holes (which should be placed with regulatory and precision) should be required. Forms shall be unblemished and panels regular. Joints shall be a feature of the pattern and shall be handled with care. Reinforcement cover blocks shall be of semi-spherical shape to minimise their appearance on the finished surface.

- (a) Smooth finishes may be obtained from non-absorptive linings to forms, form plywood, shutter board, or plastic faced board in new condition.
- (b) Boardmarked finishes shall be obtained from the use of timber planks, which shall be dressed and thickened unless otherwise specified. When unplanned timber is specified, boards with a strong grain shall be mixed with boards with a less pronounced grain and not grouped together. The Engineer shall indicate if all boards are not to be horizontal and a patterned panel effect is required.
- (c) Special patterned finishes are required to reflect without blemish the surface of patterned hardboard, rubber, thermoplastic or other lining as specified.

Class 4 – Exposed Aggregate Finishes

The purpose of these finishes is to relieve the uniform colour and texture of the concrete by exposing the aggregate, which shall be normal size concrete aggregate except where otherwise specified. Attention is directed to the necessity for allowing for the material to be removed and ensuring that the requisite cover to reinforcement is maintained.

- (a) Brushed and washed finishes are obtained by stripping and scrubbing the concrete surface with a stiff wire brush. Unless forms can be stripped at a very early age (approximately 16 hours at 20°C) this method cannot be used unless the formwork has been treated with a retarding agent. Care shall be taken to ensure that concrete is not deposited against the face of treated forms, which should be stripped as early as possible. Where scrubbing with water is not effective, a solution of hydrochloric acid in the proportion of 1 part of acid to 4 parts of water shall be thoroughly and evenly scrubbed into the surface until the desired texture is obtained. The complete surface shall then be neutralised by washing thoroughly with water to which a small amount of ammonia has been added. When acid is used, special precautions shall be taken to protect workmen, underlying materials and persons passing.
- (b) Tooled finishes may be carried out by the use of bush-hammers, light mechanical chisels or other approved tools, preferably mechanically operated. No tooling shall be done until the concrete has attained an age of at least 14 days after casting when normal Portland cement has been used and 7 days when rapid hardening cement has been used, or longer as may be necessary to prevent the aggregate particles from being dislodged.

The final finish shall show a surface of evenly distributed coarse aggregate particles set in a matrix of mortar, each aggregate particle being in slight relief. After the tooling has been completed, the surface so treated shall be scrubbed down with a stiff brush and washed with water.

- (c) Sand blasted finishes shall be obtained by sand blasting the thoroughly cured concrete surface of the same ages as given under (b) Tooled Finishes with hard sharp sand to produce an even, fine clean surface in which the mortar has been cut away, leaving the coarse aggregate exposed.
- (d) Aggregate transfer finishes may be effected by sticking a single layer of selected aggregate onto ply board or other suitable form liners which have been cut to size and coated with a layer of water soluble cellulose adhesive mixed with plaster sand. This layer should be just thinner than half the average least dimension of the aggregate. When the glue is set the liners are placed in the forms which are then concreted, care being taken to protect the forms when placing and compacting. Liners shall be stripped after at least 3 days and the adhesive and sand covering the aggregate removed by scrubbing and washing.

Class 5 – Applied Finishes

It is essential that all surfaces on which applied finishes are to be used shall be sound, clean and free of mould oil.

Defects shall first be made good.

- (a) Rendered finishes require a good key. Unless otherwise specified this may be provided by flicking on to the previously soaked and still moist surface of 1 part cement to 2 parts of sharp sand. This shall be left untouched apart from curing.

The render coat shall consist of 1 part Portland cement, or Portland 15, ½ part slaked lime, 4 to 4½ parts of sand by volume and shall not be less than 5mm or more than 16mm in thickness.

If a second coat is required because of the irregularity of the concrete, the surface of the first coat shall be combed with uniform wavy lines to provide a key after it

has begun to harden. The second coat may be applied the next day. If a scraped finish is specified the rendering shall be lightly scraped to achieve the desired affect with an old tenon saw blade or similar implement, after it has attained a biscuit like crispness. It shall then be lightly brushed and washed to remove loose particles.

All rendered finishes shall be cured.

- (b) Painted finishes of the type specified shall be applied strictly in accordance with the paint manufacturer's instructions. Very smooth surfaces shall be acid washed, lightly sand blasted or rubbed with abrasive stones before being painted. Painting shall be delayed as long as possible and two coats applied unless otherwise specified.

Concrete Upper surface Finishes

Classification

Surface finishes to exposed (non-formed) concrete faces shall be classified as hereunder –

- Class 1 – screeded finish
- Class 2 – broomed finish
- Class 3 – wood float finish
- Class 4 – steel trowel finish

Class 1 – Screeded Finish

Immediately after placing, the concrete shall be screed with a true edged wooden board working between forms or other guides set accurately to line and level. No mortar shall be added and noticeable surface irregularities caused by the displacement of coarse aggregate shall be made good by re-screeding after removing or tamping down the interfering aggregate.

Class 2 – Broomed Finish

Immediately after placing, the concrete shall be screed as in Class 1. Thereafter, when the concrete has begun to dry, the surface shall be broomed with a stiff broom or brush to expose the aggregate. Dust and loose particles shall be gently washed away once the desired relief has been obtained.

Class 3 – Wood Float Finish

Immediately after placing, the concrete shall be screeded as in Class 1. Thereafter, when the concrete has begun to dry, the surface shall be brought to a smooth and even finish using a wood float and including any additional 4:1 sand and cement as necessary.

Class 4 – Steel Float Finish

Immediately after placing, the concrete shall be screeded as in Class 1. Thereafter, when the concrete has begun to dry, the surface shall be brought to smooth and even finish using a steel float and including any additional 4:1 sand and cement as necessary.

Add the following:

Shutter release oil or any other contaminants will not be permitted on any of the reinforcing steel.

Wedges and clamps shall be used in preference to nails for securing the form components and wire ties or tie bolts in reinforced concrete must be capable of complete removal after use, except as otherwise specified. Where oil is used it shall be applied before any reinforcement is placed in position.

PSG 5.2.5 Removal of Formwork

PSG 5.2.5.2` Replace the entire contents with the following:

Where test cubes to determine stripping times are not made, the minimum periods, which shall elapse between the time of the placing of the concrete and the time of removal of the forms shall, unless otherwise agreed with the Engineer, be in accordance with the table hereunder, where each day covers a full 24 hour period.

Minimum stripping time in days:

	CEM 1	CEM 1	CEMII/A & CEMII/B (max 29% extender)	CEMII/A & CEMII/B (max 29% extender)	CEMII/B (30-35% extender)	CEMII/B (30-35% extender)
TYPE OR STRUCTURAL MEMBER OR FORMWORK	Normal weather (Above 15°C)*	Cold weather (Below 5°C)*	Normal weather (Above 15°C)	Cold weather (Below 5°C)	Normal weather (Above 15°C)	Cold weather (Below 5°C)
Beam sides, wall or unloaded columns	1	2	2	4	2	6
Slabs, with props left underneath	4	7	5	8	6	10
Beam soffits, props left under	7	12	8	14	10	17
Removal of slab props	10	17	10	17	12	21
Removal of beam props	14	21	14	21	18	28

*Average daily temperature of the atmosphere adjacent to the concrete as measured by a maximum and minimum thermometer. When the average daily temperature is between 5°C the minimum stripping times shall be interpolated from the table.

The table assumes that the member concerned is not subjected to any heavy construction loads and that the total force to be supported is not more than half the design load. Where heavier loads are to be carried, no stripping of soffits shall be permitted until the concrete has attained its full strength. Any days during which the average temperature was below 2°C shall be completely disregarded.

In the case of walls and columns the stripping times shall be determined by means of cube test results in the first instance, so as to ensure that no damage is caused to the structures by removing formwork.

PSG 5.2.5.6 THERMAL SHOCK AND THERMAL CONTRACTION CRACKING

When it is possible that a temperature differential of 20°C or more may exist within the concrete or between the concrete surface and its surroundings, special precautions shall be taken by the Contractor to avoid thermal shock or thermal contraction cracking. The advice of specialists in the field of concrete technology will be sought and their recommendations regarding the peculiar set of circumstances will be implemented.

PSG 5.4 PIPES AND CONDUITS

Add the following:

The clear space between pipes of any kind embedded in reinforced concrete and the clear space between such pipes and reinforcement shall not at any point be less than 40mm or 5mm plus the maximum size of coarse aggregate, whichever is the greater.

The puddle flanged inlet, outlet, drainage and scour pipes shall be fixed in line and position under and in the walls by the Contractor as shown on the drawings. All pipe work shall be cast into walls at the time of pouring. The use of "windows" to cast in pipe work at a later date shall only be permitted upon approval by the Engineer.

PSG 5.5 CONCRETE

PSG 5.5.1 QUALITY

PSG 5.5.2,0 GENERAL

Add to G 5.5.2,0

The concrete shall also comply with the requirements for Durability stated in PSG 7.3.8

PSG 5.5.1.4 CHLORIDE CONTENT

Replace the entire contents of the clause with:

The chloride content, measured as Cl^- of all concrete in the structure as measured by BS 1881: 124: 1988 shall not exceed 0.2% mass cement.

The maximum chloride of the fine aggregate shall be 0.2% by mass as Cl^- as measured by SABS Method 830: 1976.

PSG 5.5.1.7 Strength Concrete

Add to G 5.5.1.7:

The cubes from the trial concrete mix are to be tested at a nominated concrete design laboratory, and only the results of these tests will be considered for approval.

The minimum content of combined cementitious material shall not be less than 375kg/m³, maximum content 450kg/m³ and the maximum water/cement ratio shall be 0,5. The Contractor shall also submit for approval the proposed slumps and the proportions in which he proposes to use the materials for each grade of concrete in each type of construction. In addition he shall state the minimum cement/water ratio in terms of total water in the mix for each grade of concrete, and the use of any admixtures.

No structural concrete shall be placed on the job until the contractor has satisfied the Engineer as to the suitability of the mixes concerned.

The Contractor shall be deemed to have satisfied himself, before tendering, of his ability to produce concrete of the required quality with available materials conforming to the specification.

Add:

PSG 5.5.1.8 BLEEDING

Concrete shall be so proportioned and the materials so selected that bleeding is kept below 0.30mm/cm² as measured by the ASTM C232 – 99 test.

Add:

PSG 5.5.1.9 SHRINKAGE

Concrete shall be so proportioned by the selection of materials that shrinkage as measured by the SABS 1085 test is kept below 0.06% when batched at the maximum slump allowed.

Add:

PSG 5.5.2,00 TEMPERATURE OF CONCRETE

The temperature of the concrete shall be measured when it is delivered to site from a batch plant or a concrete supplier and shall be within the range 10°C and 30°C. Concrete which has a temperature outside of that range shall not be place in the structure.

Add:

PSG 5.5.2,01 RATE OF HYDRATION

The rate of hydration of the cement in the concrete shall be such that the concrete can be placed and properly compacted, 2 hours after the addition of water to the mix even in hot weather. Conversely, the initial set of the concrete must not be unduly delayed by low temperature, inappropriate use of admixtures or cement type, so that bleeding is promoted.

PSG 5.5.2 BATCHING

PSG 5.5.2.1 For grade 35/26 concrete, only cement types CEM 1 (OPC, Duratech), CEM 11/A (Eagle Plus) or CEM 11/B (Structcrete, Durastruct, Surecrete) shall be used. No site blending of cement extenders will be permitted.

PSG 5.5.2.2 WATER

Replace entire contents with the following:

Dependable equipment shall be provide for measuring the mixing water either by mass or by volume to an accuracy within 3%

The accuracy of the measuring device provided shall be checked whenever required by the Engineer or his representative by allowing it to discharge into vessels of accurately known capacity.

The total quantity of water allowed for shall include the free water present in the aggregates. The moisture content of the fine aggregate shall be determined at the beginning and half way through each concreting shift, after showers of rain or at such other intervals as may be required by the Engineer.

PSG 5.5.2.3 AGGREGATES

Replace entire contents with the following:

Each size of aggregate shall be measured separately by weighing to an accuracy of 2% except where other methods are authorised or ordered by the Engineer.

Where suitable volumetric methods of measuring proportions of aggregates are permitted, these shall be checked at regular intervals, and shall take full account of bulking of the fine aggregate as delivered to the mixer. These methods shall be designed in such a manner that the consistency of the mix shall be as readily controlled as for mechanical batching.

All measuring devices shall be maintained in good order and condition, and no build-up of material on any part of the equipment shall be permitted.

PSG 5.5.3 MIXING

PSG 5.5.3.1 MIXING AT CONSTRUCTION SITE.

Add the following:

Mixing shall continue until there is a uniform distribution of the materials and the mixture is uniform in colour. The minimum period of mixing shall be not less than that recommended by the manufactures at the recommended speed and not more than 30 minutes. The entire contents of the mixer shall be removed from the drum before the materials for the succeeding batch are loaded.

Where hand mixing is permitted, the quantities of cement used shall be increased by not less than 10% over those determined for the appropriate mix design. The concrete shall be mixed on a clean and watertight platform.

PSG 5.5.3.2 READY MIXED CONCRETE

Add the following:

The concrete batching plant is to be inspected by the Engineer for compliance with SABS tolerances and his approval is to be obtained in writing before commencement of the concrete works.

A maximum delivery period of 90 minutes from the time water is added to the concrete mix to the actual discharge of concrete on site shall be permitted. The discharge period (including placing the concrete) shall not exceed 30 minutes.

The concrete slump of every truck shall be measured on delivery and shall comply with Clause SABS 1200 G 5.5.1.2 prior to any concrete from that truck is placed.

A detailed computer printout of the constituents of the concrete mix from the batching plant is to be handed over to and retained by the Engineers representative on site on arrival (i.e. truck registration, mix proportions and the time water was added to the mix). The masses of the concrete constituents of each truck shall be checked against that of those submitted with the trial mix, subject to the batching accuracy as specified in SABS 0100-2: 1992. The arrival time of each truck on site and the time that the concrete discharge is completed shall also be recorded by the Engineers representative.

Before any ready-mixed concrete is used on the job, the contractor shall furnish the Engineer with a copy of his letter to the suppliers in which he specified –

- (i) The type of cement;
- (ii) The nominal maximum size of aggregate;
- (iii) The cement / water ratio;
- (iv) The required compressive strength;
- (v) The required slump at the time and place of delivery; and
- (vi) The type of additive.

All these properties shall be as specified in the contract documents.

When required the contractor shall satisfy the Engineer that acceptable alternative means of supplying concrete have been arranged to be brought into operation in the event of disruption in the supply of concrete. In this connection, the Engineer may require that the alternative means of supply shall commence if the disruption in the supply of ready-mixed concrete has lasted for and elapsed period in time of 1½ hours.

The use of ready-mixed concretes shall in no way relieve the contractor of any of his responsibilities for providing concrete complying with the specifications.

For grade 35/26 concrete, a CEM I or CEM II cement may be blend with pulverised fly ash (PFA) or ground granulated blast furnace slag (GGVS) and/or condensed silica fume (CSF), such that the combined cementitious material comprises not less than 65% cement clinker and a maximum of 35% of extender and/or other additional constituents by mass. The minimum content of combined cementitious material shall not be less than 375kg/m³ and the maximum water/cement ratio shall be 0,5.

The concrete mixes for the abovementioned grades of concrete shall be designed by an approved concrete design laboratory. At least four weeks before placing any structural concrete on the site, the Contractor shall supply and deliver to the laboratory, at his own cost, samples of the aggregates and the concrete mix design he proposes to use for the works. The Contractor shall include in his tender all fees and charges levied as well as all other costs incurred in designing the required strength concrete mix.

PSG 5.5.4 TRANSPORTATION

Add the following:

Containers for transporting concrete shall be cleaned of all hardened concrete and foreign material.

During transportation the concrete shall be protected from wind and sun; shall be prevented from drying out or losing moisture and shall not be subjected to excessive jarring or jolting. Drying out may be prevented by the provision of covers and / or other protective devices.

PSG 5.5.5 PLACING

Add the following:

Where plums are permitted they shall be deposited by hand.

Freshly placed concrete shall be protected from rain damage.

No concrete shall be placed if the air temperature in the shade is below 8°C. Concreting shall not commence if the air temperature in the shade is above 35°C. The temperature of the concrete at the point of placing shall not exceed 30°C unless otherwise specified.

PSG 5.5.5.10 STRUCTURAL CONCRETE

During the whole or any time that the placing of concrete is being carried out, the concreting operation shall be under the supervision of a suitably experienced person.

The wall footings shall be cast with wall starters to form a horizontal wall construction joint as shown on the drawings. The construction joint between footing bays shall also be as shown on the drawings. At least 3 days shall elapse between pouring adjacent wall footings.

After the wall footings have attained a minimum strength of 18 MPa, but not later than 7 days, each bay of the wall section shall be cast to full height on the same day and vertical construction joints between bays shall be formed as shown on the drawings. At least 3 days shall elapse between the pouring of adjacent wall panels.

As soon as possible after the removal of the formwork in vertical joints or after the concrete has set in horizontal joints the surface laitance of the concrete shall be removed in order to expose the large aggregate and leave a solid surface.

Openings may be left in the formwork on the outside face only for pouring and vibrating of the concrete provided they are closed properly and do not impair the concrete finish.

When concreting walls, care shall be taken to ensure that there is no loose matter on the concrete surface and that it is slightly wetted in order to assist the new concrete adhering to the existing concrete.

The Contractor's attention is particularly drawn to the fact that the walls form part of a water retaining structure and that no honeycombing will be tolerated. In order to ensure this, the mix proportions of the first 250mm depth of concrete placed in contact with the horizontal joint may be adjusted, with the approval of the Engineer, by reducing the amount of coarse aggregate. The Engineer's representative may instruct the use of trunking in placing the concrete to avoid losses of fines due to adherence to reinforcement and formwork. The concrete shall be placed evenly over the surface to be covered without reliance on vibration to transport horizontally. Special care shall be given in order to ensure full compaction at water stops.

The floor shall be cast in panels as detailed on the drawings. Consecutively cast panels shall not adjoin one another. The floor panels shall be cast in a checkerboard pattern with a minimum of 3 days between the pouring of adjacent panels.

The column and column head shall be cast in one lift. The base of the column may be cast first provided a centrally placed starter is incorporated.

The contractor may use alternative means of construction which shall be subject to the approval of the Engineer. If the Engineer accepts any alternative means of construction it shall in no way result in increased costs.

PSG 5.5.6 COMPACTION

Add:

PSG 5.5.6.5 If required by the Engineer, the concrete shall be re-worked by re-vibration 1 to 3½ hours after placing. The time shall be decided by the Engineer, taking cognisance of the mix, the ambient temperature and the workability of the concrete.

PSG 5.5.7 CONSTRUCTION JOINTS

PSG 5.5.7.1 Add the following:

Any additional construction joints required by the contractor shall be approved by the Engineer. Where "off the form" finishes are specified, joints shall be arranged to coincide with the edges of boards or panels wherever possible.

Only those construction joints shown on the drawings shall be measured and paid for. The contractor shall allow in his pricing for any additional construction joints that he may require.

PSG 5.5.7.3(b) Construction Joints when concrete is more than 24 hours but not more than 3 days old.

Delete and replace with the following:

The surface of the concrete shall be sandblasted or chipped with a light hammer, swept clean and thoroughly wetted. In addition, the first layer of concrete placed in walls over a depth of approximately 250mm shall be made richer by reducing the amount of coarse aggregate by 25%.

PSG 5.5.7.4

Add the following:

- a) All horizontal and vertical construction joints shall be cleaned of all dirt and loose particles and shall be prepared to the satisfaction of the Engineer. Formed keys shall be provided if shown on the drawings or if instructed by the Engineer. All intersections of construction joints with concrete surfaces which will be exposed to view shall be made straight and level or plumb and shall be constructed to the details shown on the drawings.
- b) The Contractor is to provide a compressor (with oil traps) on site for the whole period during which concreting is in progress, and this must be available for cleaning concrete faces prior to placing fresh concrete or pouring joints. The cost of this plant and operation is to be allowed for in the Contractor's rate for concrete.
- c) "Blowing-off" may generally be carried out on horizontal surfaces but, under special circumstances approved by the Engineer, it may be carried out on vertical surfaces.

The surface concrete to be prepared shall be between 4h and 8h old after completion of placing and shall be blown of using a mixture of air and water under a pressure of at least 500kPa or by using a high pressure water jet until all dirt, laitance, etc is removed and particles of clean coarse aggregate are exposed sufficiently to produce a rough surface. Any loose particles of coarse aggregate shall also be removed. The success of this method of preparation depends on selecting the correct time (dependant on the type of cement and atmospheric conditions) so that the concrete has set to just the necessary degree of hardness. The operation may therefore require to be undertaken outside normal working hours and at night. When the surfaces are at least 12h old any remaining loose or fine aggregate particles shall be washed off.

- d) The removal of all surface laitance plus roughening the concrete surface with hand tools in order to expose the coarse aggregate in a uniform pattern, is to be carried out on both horizontal and vertical surfaces. These areas should then be cleaned with a stiff brush under running water. The surfaces to be prepared in this manner shall be at least 12 hours old after mixing the concrete. At least 35% of the roughened surface area shall consist of exposed coarse aggregate.
- e) All prepared surfaces shall be kept continuously wet until the next lift of fresh concrete is to be placed against them; the minimum time being 12 hours.
- f) No fresh concrete shall be placed on the top surface of concrete which is laterally restrained (e.g. by formwork or by in-situ earth) while the bottom layer of concrete is between 3 hours and 12 hours old after mixing. No fresh concrete shall be placed on top of the concrete with an unrestrained lateral surface while the bottom layer of concrete is between 2 hours and 12 hours old after mixing.

The internal surface of joints in the reservoir floor and walls shall be sealed with a surface mounted "Hypalon" bandage system having an epoxy fixing system, all materials and procedures conforming to the "Sikadur-Combiflex" surface sealing system as produced by Sika (Pty) Ltd, or similar approved. The Contractor must ensure that where one Hypalon joint intersects another (at right angles or otherwise) that the two layers of intersecting Hypalon are not epoxied to each other and thereby restrained from moving. i.e. The Hypalon inside an intersecting joint must not be restrained by the epoxy adhesive and the full intended width should be free to move in the intended directions.

A 1mm thick Hypalon bandage is to be used on walls less than 6.5m and a 2mm thick bandage is to be used on walls greater than 6.5m.

The construction joints on the top (and sides where detailed on the drawings) of the reservoir roof slab are to be sealed with a 75mm wide self adhesive aluminium foil strip (Bostik "Ditsit" or similar approved) which shall be installed in accordance with the manufacturer's instructions. The "Ditsit" is to be taken over the edge of the roof slab and down the side of the wall for a distance of 500mm.

The construction joints on the soffit of reservoir roof slab are to be sealed with 2 coats of a 75mm wide application of Sika Top-Seal 107 (or similar approved) applied in accordance with the manufacturer's recommendations. The soffit of the reservoir is to be ground down 1.5 to 2mm with an angle grinder and then wire brushed and sprayed clean with water. The slurry is to be applied to a damp surface.

PSG 5.5.7.5 WATER STOPS

Water stops are to be placed in all wall and floor construction joints to the manufacturer's specification. The waterstop in the floor joints will be "rearguard" type "Expandite Supercast Rearguard R" or similar approved and in the walls will be

“dumbbell” type “Expandite Supercast Watafoil” or similar approved as specified on the drawings.

Water stops, where specified, shall be placed or kept in position as shown on the drawing. Care shall be taken during concreting to ensure that waterstops are not displaced, bent over or punctured.

All waterstops shall be manufactured from virgin polyvinyl chloride that complies with the following minimum performance requirements:

Tensile strength	12,2Mpa	(min)
Elongation at break	250%	(min)
Water soluble content	0,15%	max)
Softness (BS 2571)	38 to 50	

They shall be of the dumb-bell type and eyeleted or supplied with metal clips for the purpose of accurately fixing the waterstops between the reinforcement.

In each construction joint 150mm wide PVC waterstops shall be placed as shown on the drawings.

All intersection points shall be factory made pieces.

All joints in straight lengths and between straight lengths and intersection places shall be hot welded in accordance with the manufacturer's instructions. Jointing other than by hot welding will not be permitted.

Waterstops shall be carefully positioned and tied to the reinforcement to prevent displacement. Every precaution shall be taken to ensure maximum compaction around the waterstop. The waterstops shall then be returned to their horizontal positions ensuring that no voids are formed beneath them.

PSG 5.5.8 CURING AND PROTECTION

Add to G 5.5.8 (d):

Free from rents and tears and lapping by not less than 150mm, the surface being resprayed whenever any sign of drying out is evident.

Replace entire contents of G 5.5.8 (e) with:

Covering with an inner hessian membrane and an outer plastic membrane. The hessian membrane is to be kept continuously damp by an independent automatic sprinkler system. The hessian and plastic membranes are to be firmly secured and kept flush to the concrete surface at all times.

Add the following:

PSG 5.5.8 (f) Retaining forms in place

PSG 5.5.8 (g) Steam curing may be used on approval as specified by the Engineer, provided that the rate of increase in temperature does not exceed more than 20°C per hour. Steam curing at higher than atmospheric pressure shall not be permitted if the concrete contains limestone aggregate. Humidity shall be kept between 90% and 100%.

PSG 5.5.8 (h) the use of curing compounds will not be permitted

Delete the last two sentences of G 5.5.8 and replace with:

The minimum period of curing various types of cement shall be as follows from the date and time of casting:

- | | | |
|--------------------------------|---|---------------------|
| (a) CEM 1 | - | 7 DAYS (168 hours) |
| (b) CEM 11 (max.29(% extender) | - | 8 days (192 hours) |
| (c) CEM 11 (30-35%) | - | 10 days (240 hours) |

During periods of extreme temperatures, these periods may be increased at the discretion of the Engineer. The temperature of concrete shall be retained above 5°C for a period of 3 days after placement. Should the environment in which the concrete is placed be such that temperatures drop below 5°C in the concrete, then use shall be made of insulated formwork to retain the heat generated by cement hydration within the concrete.

Curing methods to be utilised for water retaining structures

Concrete Element	Curing Method
Reservoir floor slab	G 5.5.8 (a), (b) or (d)
Reservoir walls	G 5.5.8 (e)*
Top surface of the reservoir roof slab	G 5.5.8 (d)
Soffit of the reservoir roof slab	G 5.5.8 (f)
Reservoir columns	G 5.5.8 (e)*

*-As amended

The rates for "Curing of Concrete" in the Schedule of Quantities will be paid to the Contractor on the successful outcome of the durability tests.

PSG 5.5.9 ADVERSE WEATHER CONDITIONS

PSG 5.5.9.2 Delete reference to 32° and replace 30°C.

PSG 5.5.9.4 WEATHER STATION

The Contractor is to provide equipment to monitor the wind speed, humidity, temperature and hence calculate evaporation rates at the site. If the rate of evaporation in site exceeds 0,5kg/m²/hour, exposed concrete surfaces shall be protected to prevent plastic cracking. It should be noted that plastic cracking may occur in cool weather with high wind velocities as well as in warmer weather conditions. If in the opinion of the Engineer, the weather conditions are too extreme and run the risk of adversely affecting the concrete, he may instruct the Contractor not to pour any more structural elements that day. The Engineer may call for protection against the wind to be provided, or the finished concrete to be covered with a plastic sheet or a fog spray to be utilised.

Similarly, if it appears likely to rain, the Engineer may instruct the Contractor not to pour any further concrete. An extension of time (without P and G costs) may be allowed at the Engineer's discretion for delays incurred due to inclement weather. Any additional costs for these delays and/or protective measures are to be allowed for in the Contractor's rates for concrete work.

PSG 5.5.10 CONCRETE SURFACES

Add:

PSG 5.5.10.4 The Contractor shall make every effort to prevent blowholes from appearing on the off the form smooth finish. All noticeable defects shall be repaired to the Engineer's satisfaction.

PSG 5.5.14 DEFECTS

Add the following to G 5.5.14.1

Water retaining concrete shall be as dense as possible and no honeycombing will be permitted. If honeycombing is found to be a problem the Contractor shall re-assess the concrete mix proportions and his concrete placing methods. No additional payment shall be made for using this mix.

Add the following to G 5.5.14.2

All concrete repair work will be carried out as described below. Repair mortars containing PVA Latexes shall not be used in any water retaining structures.

1. Honeycombing:

The area to receive patch material shall be primed with a bonding slurry (e.g. Sika Mono Top 610 or similar approved). The patch will then be built up while the slurry coat is still tacky by means of an approved cementitious polymer modified mortar (e.g. Sika Mono Top 615 HB Prostruct 528 or similar approved).

2. Shrinkage cracks:

A low viscosity solvent free structural epoxy resin is to be used to fill the cracks (e.g. Sikadur 52, ABE Epidermix 365/389 or similar approved).

PSG 5.5.14.3 PATCHING AND REPAIR

Where defects do not warrant the removal of defective concrete, one or more of the following procedures shall be required by the Engineer:

- (a) Where the structural strength might be affected and must be restored, repairs may be effected by the application of either pneumatically-placed mortar or of a mortar made of silica sand and an approved epoxy formulation mixed and applied in accordance with the manufacturer's recommendations.
- (b) Where there are no fears as to structural strength, all defective material shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feathered edges shall be cut away to form surfaces perpendicular to the concrete face. Seized shutter bolts shall be cut back to at least 35mm into the concrete. All loose material shall be hosed away and the surface of the cavity shall be saturated with water for at least 3 hours, after which a thin layer of neat cement mortar shall be applied to the surface. The cavity then shall be filled with stiff mortar mixed in the same proportions of cement to sand as

that used in the original concrete. The mortar shall be thoroughly tamped into place in layers. The use of up to 30% white cement in place of the normal cement may be required to reduce the darker appearance of a patch. An interval of thirty minutes shall then elapse before a final surface tamping is given to the patch, after which the surface shall be treated to resemble the surrounding concrete as closely as possible. Board marks may be reproduced by striking a suitable piece of timber held against the plastic concrete. The patch shall be neat and workmanlike in appearance and after completion it shall be kept wet for a period of at least three days.

The cost of repairing any defective concrete shall be to the Contractors account.

The preparation, application and curing of the above repair materials shall all be in strict accordance with the Manufacturer's instructions.

Add the following Clause:

PSG 5.5.16 NO-FINES CONCRETE

Only sufficient water shall be added to the mix to produce a smooth grout to completely cover each and every particle of aggregate.

Proportions may be varied on site with the approval of the Engineer to obtain a more satisfactory result. The upper surface on the no-fines is to be finished off with a wood float to provide a smooth working surface while adding just sufficient dry mix cement-sand mortar 1 to 8 ratio to close the upper surface of the voids in order to prevent ingress of foreign matter and concrete from the blinding/floor concrete into the interstices.

Mixing shall be carried out in a mechanical batching plant and the hopper shall first be charged with the aggregate to which a small quantity of water has been added to moisten aggregate particles. The cement shall then be added followed by the remainder of the water.

The no-fines concrete shall be placed within 20 minutes of having been mixed and shall be rodded and hand tamped into position. The use of vibrators will not be permitted.

No traffic shall be permitted to traverse the surface of the no-fines concrete during the three days following upon placing and thereafter only over planks or boards placed for that purpose.

No-fines drains shall be measured per metre and shall include for the porous concrete pipe and the encasement in no-fines concrete.

No-Fines Concrete

General

Unless otherwise specified, no-fines concrete shall only be used for non-structural work.

Grading of Aggregate

Aggregates for no-fines concrete shall be graded so that not more than 10% by mass of aggregate is retained on a sieve having 19mm square openings and not more than 5% by mass passes a sieve having 9,5mm square openings.

Mix proportion

No-fines concrete shall be mixed with one part of cement to 9 parts of aggregate.

PSG 6 TOLERANCES

PSG 6.2 PERMISSIBLE DEVIATIONS

PSG 6.2.3(a) Replace with the following:

Description	Permissible Deviation in mm	
	Degree	
	III and II	1
Spacing between two adjacent bars	± 20	± 15
Dimensional position of bar	± 20	± 10
Longitudinal location of bends and ends of bars	± 30	± 20
Cover to reinforcement	-0 + 10	-0 + 5

PSG 6.2.3(h) Add:

Tolerances for bow or camber, twist, squareness and for silos and skip form concrete, pre-stressed concrete and precast concrete will be stated in Part Project Specification wherever applicable.

PSG 7 TESTS

PSG 7.1 FACILITIES AND FREQUENCY OF SAMPLING

PSG 7.1.2 FREQUENCY OF SAMPLING

PSG 7.1.2.2 Replace the entire contents of the clause with:

The Contractor shall provide the following number of sets of three standard metric 150mm metal cube moulds for the volume of concrete pour as per the table below:

Table 4 - Frequency of compressive strength tests

Volume of pour (m3)	Number of sets
---------------------	----------------

0 – 25	2
26 – 50	4
51 – 100	6
101 – 200	8
+ 201	10 (or as required by the Engineer)

These sets of concrete cubes will be crushed when they are 7 and 28 days old.

Provide sufficient extra cube moulds for 3 days, 7 days, etc, crushing tests to be made as he so requires for his own purposes i.e. for shutter stripping, post-stressing cables.

Make and cure all cubes on site under the supervision of the Engineer, in accordance with SABS Method 863.

Be represented at the crushing test if he so wishes.

Transport all cubes to the nominated laboratory between 7:30am and 11am on the last working day prior to the date of test. Only the results from this laboratory will be considered and will be the sole basis on which concrete is accepted or rejected.

PSG 7.3 ACCEPTANCE CRITERIA FOR STRENGTH CONCRETE

Delete the entire contents of G 7.3.1 and G 7.3.2 and replace with:

PSG 7.3.1 The Contractor is hereby advised that the basis, on which concrete will be accepted or rejected, is on the 28-day cube strength obtained from cubes crushed at the nominated laboratory. Unless the conditions of sampling, cube manufacture, cube curing and record keeping are strictly adhered to, the test results will be meaningless. To this end it is emphasised that the Contractor must strictly comply with all the concrete test methods specified in SABS Method 861.

Table 5 - Acceptance criteria for concrete strength

Acceptance Category	Strength Cs = Average minimum strength for 3 cubes at 28 days (Mpa)
Characteristic strength for water retaining structures	35
Full acceptance	$C_s \leq 37$
Conditional acceptable	$33 \geq C_s > 37$
Rejection	$33 < C_s$

The descriptions given in the "Acceptance Categories" column above shall have the following meanings.

Full acceptance - Concrete shall be accepted unconditionally, subject to the concrete meeting the durability and cover criteria.

Conditional acceptance - Concrete shall be accepted with a warning that construction methods should be examined to improve the strength. A financial penalty of up to R75/m³ will be applied on a pro rata sliding scale for all concrete poured where the average strength (for 3 cubes at 28 days) test results fall within the conditional acceptable range.

Rejection - At the discretion of the Engineer, the concrete shall be removed and replaced at the expense of the Contractor.

Core holes - That test cores shall be drilled from the concrete and tested in accordance with the SABS Method 865 to determine the estimated actual strength and the estimated potential strength of the concrete.

If the results of the core tests show that the concrete meets the test requirements, the structure shall be accepted. If the cores tests show that the concrete does not meet the strength requirements, an appropriate full-scale load test, as determined by the Engineer, shall be applied on the structure containing the defective concrete.

If load tests are, in the opinion of the Engineer, impracticable, or where the portions of the structure subjected to such test fail to pass the test specified, he shall have the right to require strengthening or replacement of the portions of the structure concerned.

Upon removal of the core the hole is to be dampened and filled with a stiff mix of an expanding cementitious grout (Sika Grout G.P. or similar approved). Thereafter, an external slurry coat (0,25 x 0.25m) of a polymer modified cementitious coating (Sika Top-Seal 107 or similar approved) is to be applied over the exposed surface of the core hole.

PSG 7.3.5 REPLACEMENT OR STRENGTHENING OF CONCRETE

Delete after the words "the Contractor shall", and insert

"make adjustments in order to meet the specified requirements."

Add:

PSG 7.3.6 Table 8 – Acceptance criteria for concrete cover

Acceptance Category	Concrete Cover (mm) (for specified cover of 50mm)
Full Acceptance	$70 > C_d \geq 50$
Conditional acceptance	$45 \geq C_d > 50$
Acceptance with remedial measures	$40 \geq C_d > 45$
Rejection	$C_d < 40, C_d > 70$

The descriptions given in the "Acceptance Categories" column above shall have the following meanings.

Full acceptance - Concrete shall be accepted unconditionally, subject to the concrete meeting the strength and durability criteria.

Conditional acceptance - Concrete will be accepted with a warning that construction methods should be examined to improve the cover. A financial penalty of up to R15/m² will be applied on a pro rata sliding scale for each structural element where the average test results fall within the conditional acceptable range .

Acceptance with remedial measures - Concrete will be accepted if the Contractor undertakes remedial work at his expense, as approved by the Engineer, to improve the durability of the concrete to the criterion described as "full acceptance".

Rejection - At the discretion of the Engineer, the concrete shall be removed and replaced at the expense of the Contractor.

Notwithstanding Clause 29.1 of the General Condition of Contract (Removal of improper work and materials) and Clause 30 of GCC (Contractor to search), the onus will be on the Contractor to prove to the Engineer the extent of the concrete for which the durability and cover values fall below the Specified Values (in the above tables), and the cost of this searching is to be included in the Contractor's rates for concrete.

An item has been included in the Schedule of Quantities for the making good of core holes as directed by the Engineer.

Where the Engineer or his representative has reason to doubt whether the concrete cover over the reinforcement is not in accordance with the requirements of clause PSG 5.1.3, the cover shall be tested with a cover meter. If necessary, the Engineer or his representative shall then indicate to the contractor where he must expose the reinforcement to prove the depth of cover.

Add:

PSG 7.3.7 COSTS OF TESTS

The costs of all tests required by the Engineer or his representative shall be borne by the Employer except that costs of tests as set out hereunder shall be borne by the contractor -

- (a) Preliminary tests on materials and of mix proportions;
- (b) All tests as may be made necessary by reason of the provisions of clause SABS 1200 G 7.3.5;
- (c) Such tests, including concrete coring and load tests, as may in the opinion of the Engineer be made necessary by failure on the part of the contractor to meet the requirements of this specification.

Add:

PSG 7.3.8 DURABILITY INDEX TESTS

To ensure that the concrete has been placed, compacted and cured correctly, a number of tests will be carried out by a nominated laboratory on the concrete after curing has been completed ie 26 to 30 days after placing of the concrete.

- 1) A set of four 68mm diameter cores, 75mm in length will be drilled at each test location through the covercrete (being the concrete layer between the outermost layer of steel reinforcement and the exposed outer surface of the concrete element) from the constructed concrete element when the concrete has reached 28 days of age. A slice (30mm thick) will then be cut from the outer surface of this core such that the slice is representative of the middle layer of the covercrete (ie the middle layer being a 30mm thick slice of concrete, 15mm from the exposed outer surface extending in towards the reinforcement) and tested for: -

- 1.1) Water sorptivity,
- 1.2) Oxygen permeability (tested in the Ballim apparatus), and
- 1.3) Chloride conductivity

The positions at which the cores will be extracted will be indicated by the Engineer.

The oxygen permeability and water sorptivity, and chloride conductivity test procedures shall be carried out in accordance with the following references:

- (1) Guide to the use of durability indexes for achieving durability in concrete structures. (Research Monograph No. 2)
 - (2) Concrete durability index testing manual (Research Monograph No. 4)
- 2) The depth of concrete cover achieved will be measured to ensure that the specified values have been achieved.

The cost of these tests will be borne by the Employer if the results are equal to or exceed the specified value. The Contractor will pay for the tests if the results fall below the conditional acceptance range.

N.B. The employer will pay for one set of tests per test.

Table 7 – Acceptance criteria for durability testing structural element.

Acceptance Category	Oxygen permeability index (log scale)	Water sorptivity (mmh)	Chloride Conductivity
Full acceptance	$Op \geq 9.15$	$Ws \leq 8$	$Cc \leq 0.75$
Conditional acceptance	$9.0 \geq Op > 9.15$	$8 < Ws \leq 12$	$0.75 < Cc \leq 1.50$
Acceptance with remedial measures	$8.75 \geq Op > 9.0$	$12 < Ws \leq 15$	$1.50 < Cc \leq 2.50$
Rejection	$Op < 8.75$	$Ws > 15$	$Cc > 2.50$

The descriptions given in the “acceptance Categories” column above shall have the following meanings.

Full acceptance - Concrete shall be accepted unconditionally, subject to the concrete meeting the strength and cover criteria.

Conditional acceptance - Concrete will be accepted with a warning that construction methods should be examined to improve the durability. A financial penalty of up to R75/m³ will be applied on a pro rata sliding scale for each structural element where the average test results within the conditional acceptable range.

Acceptance with remedial measures - Concrete will be accepted if the Contractor undertakes remedial work at his expense, as approved by the Engineer to improve the durability of the concrete to the criterion described as a “full acceptance”.

Rejection - At the discretion of the Engineer, the concrete shall be removed and replaced at the expense of the Contractor.

PSG 7.3.9 WATER TIGHTNESS TESTING

A hydraulic test shall be undertaken on the reservoir structure before backfilling and no backfilling will be permitted before this test and the acceptance of the structure for watertightness.

All interior surfaces of the reservoir shall be broomed, cleaned and hosed down and the cleaning water run to waste.

The reservoir shall then be filled slowly at a rate not exceeding 2m in 24 hours, and allowed to stand for 7 days to allow absorption to take place. The Contractor shall allow for adding chemicals supplied by the Client to sterilize the reservoir.

The water level will be taken thereafter every 24 hours for 7 days. A maximum drop in surface level of 12mm will be permitted over the full period of 7 days. Should the structure not stand this test the Engineer may order a second test and should this fail, the Contractor shall be responsible for finding the leaks and taking such measures as necessary and approved by the Engineer to produce a satisfactory test.

Water for the second and subsequent tests will be charged to the Contractor at current tariff rates.

The lump sum price for the hydraulic testing of the reservoir shall for cleaning all internal surfaces, adding chemicals and testing.

PSHA **STRUCTURAL STEELWORK**

PSHA 1 **APPLICABLE SPECIFICATIONS:**

SABS 1200 H: STRUCTURAL STEELWORK

SABC 1200 HC: CORROSION PROTECTION OF STRUCTURAL STEELWORK

PSHA 2 **AMENDMENTS TO SUBCLAUSES OF SABS 1200 H:**

PSHA 2.1	SUBCLAUSE 3.1: STRUCTURAL STEEL The steel shall be Grade 350W for hot rolled steel sections (I, H, C, L). All members shall carry the Grade 350W steel symbol to identify steel grade prior to manufacturing, unless otherwise shown on the drawings. All other structural elements, tubular profiles, flat bars, squares, rounds, checker ("vastrap") floor plate shall be Grade 43 or as specified on the drawings. The thickness of a checker ("vastrap") floor plate, is the under-pattern thickness. All stairs, ladders and handrails shall be SS 304L or as indicated on the drawings.
PSHA 2.2	SUBCLAUSE 5.1 AND SUBSUBCLAUSE 5.1.2: CONTRACTOR PROVIDES SHOP DETAILS The contractor shall furnish the Engineer with shop-detail drawings within two weeks of having received the design drawings. The Engineer will check the drawings for conformity with design requirements and will return the drawings with additions and corrections, if any, within one week of having received them. Detailed checking of shop details for dimensional accuracy and installation fit, will not be done by the Engineer.
PSHA 2.3	SUBSUBCLAUSE 5.2.3: CUTTING The edges of flame-cut plates shall be ground smooth.
PSHA 2.4	SUBSUBCLAUSE 5.6.1: GROUTING RESPONSIBILITY Grouting shall not be done by the steel contractor.
PSHA 2.5	SUBSUBCLAUSE 5.3.4: WELDING (a) All welders shall be coded welders. The contractor shall submit welding procedures by an approved welding authority for approval and shall produce evidence acceptable to the Engineer that welding procedures and welders have been tested in accordance with the requirements of SABC 044, Parts III and IV. Approved splicing of members will be subject to non-destructive testing. The cost of testing shall be borne by the contractor. (d) The Engineer may at his discretion identify welds for non-destructive testing by an approved authority the cost of which will be borne by the Contractor.
PSHA 2.6	SUBSUBCLAUSE 8.3.6: MEASUREMENT OF AND PAYMENT FOR PROTECTIVE COATING Surface preparation, priming, shop and site painting shall be measured in m² of surface treated.
PSHA 2.7	SUBCLAUSE 7.1: TEST CERTIFICATES Test certificates pertaining to the steel to be used shall be submitted to the Engineer by the contractor before fabrication commences. The Engineer reserves the right to inspect all structural steel in the workshop before it is delivered to the site.

PSHA 2.8 SUBSUBCLAUSE 7.2: INSPECTION

Third party inspections will be executed by an independent Inspectorate appointed by the Employer on behalf of the Engineer, in accordance with the proposed detailed Quality Control Plan (QCP). Inspections will be carried out at the Manufacturer's factory during and after manufacturing, during coating, storage & handling and installation on site. The frequency of inspection is permanent on the project unless relaxed by the Corrosion and Coating Engineer (CCE) of Johannesburg Water.

PSHA 2.8 SUBSUBCLAUSE 6.2.2: OTHER TOLERANCES

Degree of accuracy II shall apply unless indicated otherwise elsewhere.

PSHA 3 ADDITIONAL CLAUSES:

PSHA 3.1 PROTECTIVE TREATMENT AND PAINTING

PSHA 3.2,0 All paint shall be delivered at the workshop as well as on the site in the original containers that display the manufacturer's name and trademark as well as the SABS mark. The Engineer may, at his discretion, prescribe the manufacturer and the type of paint.

The coating system shall be from one manufacturer only. The paint manufacturer's instructions shall be strictly adhered to.

PSHA 3.2,0.2 Surfaces in contact with each other after assembly or erection shall receive the primer beforehand, except for faying surfaces for friction-grip fasteners.

PSHA 3.2,0.3 The application of the final coats of paint before erection will be permitted by the Engineer only in special circumstances or where specified elsewhere.

PSHA 3.2,0.4 After erection of the steelwork, the specified paint system shall be reinstated in all area where it has been damaged. All fasteners shall also be treated in accordance with the specified paint system.

PSHA 3.2,0.5 No painting on the site shall be done in inclement weather or when humidity or frost is liable to cause wet or damp conditions on the surface to be painted.

PSHA 3.2,0.6 No painting shall be done if the temperature falls below 7°C.

PSHA 3.2,0.7 Welded seams shall be thoroughly steel-brushed before painting. Permission shall be obtained from the Engineer before slag residue may be neutralized with acids or alkalis.

PSHA 3.1.2 SURFACE PREPARATION IN THE WORKSHOP

SIS 05 59 00 or ISO 8501 shall apply and shall be referred to in respect of this clause.

PSHA 3.1.2.1 MANUAL SCRAPING AND WIRE BRUSHING

This treatment shall normally be applied in all circumstances except if and where blast cleaning is specified.

- Prior to treatment, the steel surface shall be cleaned of dirt and grease.
- Heavier layers of rust shall be removed by chipping.
- All loose mill scale, rust and foreign matter shall be removed by very thorough scraping, wire-brushing, machine-brushing, grinding, etc.

- Finally the surface shall be cleaned by vacuum cleaner, with clean dry compressed air, or with a clean brush.
- The surface shall have a pronounced metallic sheen with an appearance equal to or better than that shown on the prints designated ST 3 IN sis 05 59 00 or ISO 8501.

PSHA 3.1.2.2 BLAST-CLEANING

This treatment may be used but is not obligatory unless so specified hereinafter. If blast cleaning is preferred to normal scraping and wire brushing, the final surface shall be equal to or better than that specified in sub-sub clause 3.1.2.1.

PSHA 3.1.3 PAINT SYSTEM

The paint system shall be applied in accordance with the specifications given in table 3.1 below. Application may be by brush, roller or sprayed. Red lead may not be used.

All structural steel which is not visible, eg purling, rafters and trusses, shall receive only the primer coat. All visible steel shall receive the full appropriate paint system treatment.

In all cases the manufacturer's specification for any paint product must be followed.

Table 3.1 Paint system for new steel surfaces for unpolluted inland environments (not suitable for temperatures above 90°C)

Coat No	Place of application	Time of application	Min thickness in μm	Types	SABS - Specification
1. Primer	Workshop	Within 4 hours of surface treatment	50	Zink phosphate Plascoprime 182 QD (Plascon) or D193-1029 (Dulux)	(None)
2. Two final coats; colour as specified elsewhere	Site	After erection. 2nd coat within 48 hours of 1st	Each coat 25 to 40	High-gloss enamel or structural steel paint	630 Type 1 684 Type A

PSHA 3.2 PAINT SYSTEM FOR NEWLY GALVANIZED SURFACES

PSHA 3.2.1 RECOMMENDED SURFACE PREPARATION:

- Degrease with Plascon Aquasole Degreaser GR 1 or similar approved. Any cement or foreign material must also be removed from the metal surface.
- Rinse with clean running water while protecting the floors and walls.
- Wash with Galvanised Iron Cleaner GIC 1 by Plascon, or similar approved.
- Rinse with clean running water and allow to dry. Protect the floors and walls.

PSHA 3.2.2 Apply one coat of Plascon Aquafast Etch Primer no EMS 18 or similar approved to a total dry thickness of 35 micron. Must be overcoated within 72 hours to avoid excessive hardening.

PSHA 3.2.3 TWO FINAL COATS AS SPECIFIED IN TABLE 3.1

PSHA 4 HOT DIPPED GALVANIZING (See also subclause 5.9 in SABS 1200H)

Steelwork described as “hot dipped galvanised” shall be galvanised after manufacturing and before delivering to site by means of the hot dipped process complying with the minimum requirements of SABS ISO 1461, 2000 latest amendment. Structural steel members shall be given an 85 micron thick galvanised coating or such other thickness as may be specified in accordance with SABS ISO 1461 (Table 1).

Damaged surfaces must be thoroughly cleaned and if welding has been carried out all slag must be removed preferably by the use of a chisel hammer.

Before galvanising all surfaces of the metalwork shall be thoroughly cleaned of all scale and rust by shot-blasting in accordance with SABS 064 or by pickling and then fluxed ready for galvanising.

The zinc coating shall be even and continuous over all surfaces, free of bare spots, dull or rough patches, blisters or other imperfections. The zinc coating shall show no signs of peeling and shall be uniform in thickness.

All M8 and greater bolts, nuts screws and other threaded components, shall be hot-dip galvanised to SABS ISO 1461 (previously articles type C).

Repairing of damaged coatings

Plant repairs

Should any black spots or uncoated areas greater than 5 mm² (individual) or 25mm² (collective) per m² or per m run be present after galvanizing, the coating shall be repaired. This is to be carried out using abrasive blasting followed by zinc metal spray. The zinc metal spray shall be applied at least 25% thicker than that specified and shall overlap the damaged area by 20-25mm. The finished coating shall be wire brushed to remove any excess metal spray.

Hot patch soldering is an alternative at the plant but is seldomly used, as the method needs to be conducted while the product is still hot before quenching.

Site Repairs

Zinc metal spray as set out above.

The recommended alternative is to use a zinc rich paint provided it has at least 90% zinc in the dry film, by mass. The paint should be a zinc rich epoxy in conformance with SABS 926. A single pack zinc rich paint such as Plascon’s “Plascozinc Polygalv Primer” or equal can be applied.

PSL**MEDIUM-PRESSURE PIPELINES****PSL1****PIPE MATERIALS****PSL1.1****Mild Steel Pipes, Fitting and Specials**

Mild steel pipes and specials up to 150 mm nominal diameter shall comply with the requirements of SABS 62. Pipes and specials over 150 mm nominal diameter shall comply with the requirements of SABS 719.

Pipe specials shall be manufactured to the requirements of BS 534.

Mild steel pipes, fitting and specials shall furthermore comply with the following:

- a) Grade of pipe material : Grade X52
- b) Wall thickness : As specified in Schedules, but with a minimum wall thickness of not less than 4.5 mm
- c) End treatment : Plain, machined or flanged as indicated in the Schedule of Quantities and the Schedule of Steel Specials
- d) Pipe interiors : Weld reinforcement and upset material on the interior surfaces shall not exceed 1 mm
- e) Edges : All edges on pipe specials shall be rounded to a minimum radius of 3 mm prior to corrosion protection
- f) Corrosion protection : Refer Clause PSL 12 hereof
- g) Welding : Electric fusion welding

PSL1.2**Unplasticised Polyvinyl Chloride Pressure Pipes and Fittings**

uPVC pressure pipes and fittings shall conform to the requirements of SABS 966 Part 1.

All pipes and fittings shall have an integrally moulded joint with factory fitted rubber seal ring, unless other specified. Only full length pipes bearing the aforementioned markings will be acceptable. When laying pipes, the markings shall be visible from above.

uPVC Pipes and fittings must be carefully handled and stored and the Contractor must in particular observe the following.

- a) Pipes must be carefully off-loaded and under no circumstances may pipes be thrown off vehicles
- b) Pipes with socket ends must be stored on timber supports on the ground. The supports may not be placed more than 1.0 m apart
- c) Pipes may not be stacked higher than 1.0 m during transport or on stage
- d) The storage area must be level and free from stones and sharp objects
- e) The storage area must be free from dry grass or any material likely to constitute a fire hazard
- f) Pipes and fittings must always be stored in the shade; away from direct sunlight

The cost of cutting and trimming pipes shall be included in the rates for laying and jointing of pipes.

Except for bends up to 250 mm diameter, all fittings for use with uPVC pressure pipes shall be cast iron with wall thickness in accordance with SABS 546 and socket dimensions in accordance with SABS 966.

PSL1.3**High Density Polyethylene Pipes (HDPE)**

HDPE pipes shall be type IV in accordance with the requirements of SABS 533 for the working pressure as specified.

Only approved polypropylene compression fittings shall be used with HDPE pipes.

Welding fittings will not be permitted.

PSL2**ISOLATING VALVES AND STOPCOCKS****PSL2.1****Cast iron gate valves**

All cast iron gate valves shall be WEDGE TYPE gate valves of the waterworks type in accordance with the requirements of SABS 664. The valves must be able to withstand a hydraulic working pressure of 1600 kPa and shall have plain, flanged or socket ends to suit the pipeline materials and/or fittings as specified.

The valves shall be provided with a straight, unobstructed body passage through the valve and the gate shall be completely clear of the waterway in the fully open position. The sealing and gate guide shall be of substantial design to support the gate until it closes and the gate shall be manufactured of cast iron and covered with bonded vulcanised nitrate rubber. The valve shall have a non-rising stainless steel spindle fitted with a cap top or handwheel and close anti-clockwise.

The valve spindle shall be provided with a lock-seal permitting the replacement of the spindle seals under pressure. The spindle seal shall consist of at least two O-rings located in a corrosion-resistant housing. A further wiper ring to prevent the ingress of dirt shall be provided.

All components shall be interchangeable between valves of the same size and all bolts and nuts in the construction of the valves shall be galvanised standard metric hexagonal bolts and nuts.

The valves shall be able to handle flow in both directions and be installed in reversible directions and are required to seal drop-tight from zero to a maximum pressure of 1.5 times the rated working pressure under test and field conditions.

The type and make of the gate valves must be approved by the Engineer prior to ordering thereof.

PSL2.2**Butterfly valves**

Butterfly valves shall have the following features:

Body type	: Water for valves < 250 mm diameter Fully flanged for valve 300 mm diameter
Seating	: Replaceable
Dimensions	: Face-to-face dimensions must conform to the requirements
Operation	: Gearbox operation with hand wheel
Pressure rating	: Valves must be able to withstand a maximum hydraulic pressure of 1 600 kPa

Valve components shall be manufactured from the following materials:

Body	:	Cast iron or Ductile iron to SABS 936 GRSG42
Disc and shaft	:	Stainless steel
Seating and rings	:	Replaceable rubber
Bearing	:	Self-lubricating Vesconite

The type and make of the butterfly valves must be approved by the Engineer prior to ordering thereof.

PSL2.3 Brass stopcocks, ballcocks and bibcocks

Cast brass stopcocks, ballcocks and bibcocks shall be used for pipe diameters of 50 mm and smaller where specified on the drawings of Schedule of Quantities. The valves shall comply with the requirements of SABS 776, and shall be capable of withstanding a hydraulic working pressure of 1 600 kPa. The valves shall have screwed ends.

Stopcocks shall have special non-rising stems to prevent dezincification and be fitted with a handwheel for clockwise closing. The direction of the closing shall be marked on the handwheel.

The make of stopcock, ballcock or bibcock must be approved by the Engineer, prior to ordering thereof.

PSL3 SWING CHECK VALVES

Swing check valves shall be single or double door design and conform to the following requirements:

Body type	:	Wafer or flanged as specified
Body materials	:	Cast iron or carbon steel
Disk and hinge	:	Grade 316 stainless steel
O-ring	:	Nitrile rubber
Maximum working pressure	:	1600 kPa
Standard supply features	:	Counterweight and lever on door shaft Torsion spring (Iconel) to assist closing before flow reversal with lifting eye bolt.

The type and make of valve must be approved by the Engineer prior to ordering thereof.

PSL7 FIRE HYDRANT VALVES

Fire hydrants shall be tamper proof with a 65 mm diameter double aluminium alloy quick coupling complying with the applicable requirements of SABS 1128, Parts 1 and 2, and equipped with a squire spindle on which the keys of the local fire brigade shall fit. It shall furthermore comply with NBR 85, T-section, no 9613, dated 1 March 1985.

After installation of the fire hydrants they shall be painted with one undercoat of zinc chromate or a similar product complying with the applicable requirements of SABS 679, followed by two coats of medium yellow high-gloss enamel paint such as Plascon Code G6 or an approved similar product which conforms to the requirements of SABS 630.

PSL8 PRESSURE GAUGES

Pressure gauges for monitoring water pressure in pipeline shall be glycerine-filled robust and shall comply with the following requirements.

Case	:	Solid brass forging with integral bottom entry stem and pressure vent in back of case.
Window	:	Non-splintering clear plastic
Dial	:	White aluminium with black lettering
Pointer	:	Black aluminium with black lettering
Bezel ring	:	Roll formed stainless steel ring
Connector	:	½" BSP male bottom entry connector
Scale range	:	0 to 1 600 kPa

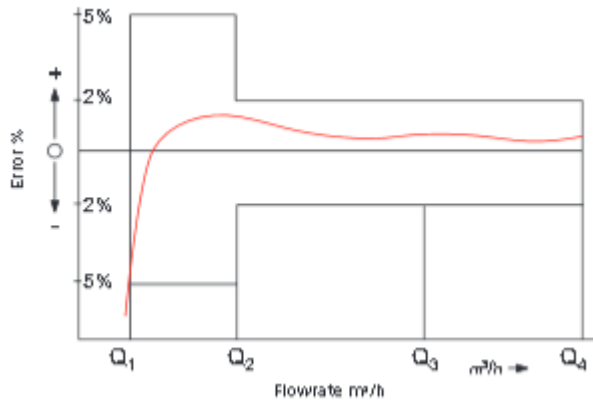
The size of gauge is specified on the drawings and/or in the Schedule of Quantities.

PSL9 WATER METERS

PSL9.1 In-line Full Bore Electromagnetic Field Flow meter

These types of meters are installed in-line using flanges and do not require the use of a strainer. Meters must comply with the following requirements:

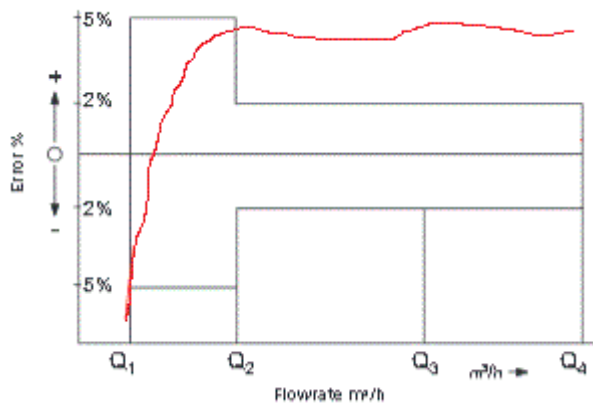
1. Meter must be ISO7145, ISO4064|OIML R49 approved and must be delivered with a certificate of calibration.
2. Meter flanges must comply with SABS1123 Table 1600/3.
3. Meter must have a dual pulse (forward and reverse), 4-20mA and must have a Modbus output standard (HART optional add-on).
4. Meter must be able to be installed horizontally and vertically.
5. Meter must be PN16.
6. Meter must be able to work up to 70°C.
7. The enclosure sensor must be IP68 or higher.
8. Meters must comply with Johannesburg Water's metering policy.
9. The meter must be able to measure forward and reverse flow.
10. The meter needs to have an error of less than 0.5%



PSL9.2

Clamp-On Ultrasonic meters

1. Meter must be ISO7145, ISO4064|OIML R49 approved and must be delivered with a certificate of calibration.
2. Meter must have a dual pulse (forward and reverse), 4-20mA and a MODBUS RTU with RS485 output standard (HART optional add-on output).
3. Meter must be able to be installed horizontally and vertically.
4. Meter must be able to work up to 50°C.
5. The meter needs to have an error of less than 5% as shown in the below graph.



6. The transducers need to be IP68 rated.
7. Meters must comply with Johannesburg Water's metering policy
8. Meter Housing needs to be IP68.
9. Meter needs to have a digital display showing totals.
10. Meter needs to be able to run off 24V DC.

Where meter is located in a remote area meter is to be battery operated (refer to section Telemetry)

11. Meter needs to be able to record forward and reverse flow.

PSL10 SURFACE BOXES AND VALVE BOXES

PSL10.1 Cast iron surface boxes

Surface boxes, covers and frames of cast iron for valve chambers shall comply with the requirements of SABS 558.

PSL10.2 Step irons

Step irons shall comply with the requirements for malleable cast iron of BS 1247, figure 1 and shall be fully coated with a high density polypropylene cover. The length of the step irons shall be suitable for fixing in brickwork or in situ and precast concrete.

PSL10.3 Precast concrete chambers

Precast concrete chambers shall consist of reinforced concrete chamber sections of circular shape, manufactured in accordance with the requirements of SABS 677 with the following minimum wall thickness:

<u>Nominal diameter (mm)</u>	<u>Wall thickness (mm)</u>
750	60
1 000	65
1 250	75
1 500	90

The circular chamber sections shall be firmly embedded into a class 20/19 MPa cast in situ foundation as specified on the drawings.

The chambers shall be fitted with a precast reinforced concrete slab of thickness not less than 150 mm or as specified on the drawings.

All joints will be sealed with "Prostruct 687" or "Araldite BV1057" epoxy sealant.

PSL11 JOINTING

PSL11.1 Flanged Connections

PSL11.1.1 Flanges

All flanges shall be to SABS 1123 and drilling to Table 1600/3 unless otherwise specified.

PSL11.1.2 Bolts and Nuts

Bolts and nuts (GR4.6) shall be coarse pitch thread with hexagonal head in accordance with the requirements of SABS 136 and shall be hot –dipped galvanised to SABS 763, 6HZe. All bolts must be of equal length and the length of each bolt shall be such that, after the nut has been tightened, the end of the bolt shall project above the nut by not less than one full thread and not more than four threads.

PSL11.1.3 Flange gaskets

All gaskets for flanged joints shall be 3 mm thick, full face rubber insertion in accordance with the requirements of BS 3063.

PSL11.2 Flexible Couplings

All flexible couplings for plain-ended steel pipes and fittings shall be of the slip-on type without centre register, such as Viking Johnson or an approved similar product, and shall comply with the relevant requirements of BS 534.

PSL12 CORROSION PROTECTION

The corrosion protection specified hereafter applies to all surfaces (internal and external) unless otherwise stated.

PSL12.1 Steel pipes and Specials

PSL12.1.1 Steel pipes and fittings up to and including 50 mm nominal diameter shall be hot-dipped galvanised to the requirements of SABS 763, unless otherwise specified.

PSL12.1.2 Steel pipes and specials over 50 mm nominal diameter shall receive the following corrosion protection:

a) Surface preparation

Surfaces to be treated shall have all projections, sharp edges, laminations and tool marks removed to provide a smooth surface and shall be cleaned in accordance with section 2, 3 and 4 of SABS Code of Practice 064 to meet the following requirements.

- (i) A cleanliness of not less than Sa 2½ when tested according to SABS test method 767.
- (ii) A surface profile not exceeding 0.09 mm when tested according to SABS test method 772.
- (iii) Free from dust and debris not more than 0.2 % when they are tested according to SABS test method 769.

The Contractor shall furnish the Engineer with the manufacturer's written warranty that the above requirements have been met.

b) Epoxy coatings

Epoxy coatings and linings shall be applied to the surfaces as specified strictly in accordance with the epoxy manufacturer's instructions and shall comply with the requirements of SABS 1217.

The Contractor shall furnish the Engineer with a certificate which confirms that the coatings have been applied to the manufacturer's satisfaction. Such certificate shall be signed by the manufacturer and the Contractor.

The epoxy system to be used will consist of the following as specified on the drawings:

- (i) Internal lining:
Fusion Bonded Epoxy (SANS 1217 Type 2A material) with target thickness of 400microns and (± 100micron max.)

- (ii) External coating for buried pipework:
Fusion Bonded Epoxy (SANS 1217 Type 2A material) with target thickness of 400microns ($\pm$ 100micron max.)
- (iii) External coating for above ground pipework:
 - a. Layer 1: Fusion Bonded Epoxy (SANS 1217 Type 2A material) with target thickness of 400microns ($\pm$ 100microns max.)
 - b. Layer 2: Top coat layer of re-coatable polyurethane paint with target thicknss of 50microns ($\pm$ 10microns max.) according to Joburg Water colour code for Waterworks.

c) Inspection of epoxy coatings

After completion of lining and coatings in the factory, the steel pipes and specials shall be inspected by an independent Inspector appointed by the Engineer to confirm the integrity of the coatings as specified. No steel pipes and specials may be delivered to site until such time that the coating system has been inspected and approved in writing by the Engineer.

d) Protection, Handling, Transport and Storage of Shop Lined, Coated Pipes and Specials

After the linings and coatings have passed all inspections and tests, all ends shall be covered and kept covered up until the installation of the pipe or special in the field. End covers shall consist of heavy gauge plastic sheeting or other approved material lapping the ends of the pipe and secured to the outside of the pipe with flat steel binding strips. A single 100 mm long slit shall be cut in the centre of each of the two end covers of each pipe special. End covers to branch ends shall not be slit.

Lined and coated pipes and specials shall be protected against damage at all stages from manufacture to delivery and laying. End covers shall be maintained until ends are jointed. Pipes and specials shall be lifted only by means of broad band slings. During transport pipes and specials shall be supported on padded cradles or saw dust filled bags. Under no circumstances shall coated pipes and specials be placed directly on the ground or unpadded hard surfaces.

PSL12.2 Cast Iron Valves and Fittings

An epoxy coating system as specified in clause PSL12.1.2 above.

PSL12.3 Flexible Steel Couplings

An epoxy coating system as specified in clause PSL12.1.2 above.

PSL12.4 Bolted or Screwed Connections Below Ground Surface

Bolted connections (flanges and flexible steel coupling) or screwed connections buried below ground surface shall be protected by wrapping petrolatum impregnated cloth tape around the complete connection after installation.

PSL12.5 Galvanised Pipes and Fittings Below Ground Surface

Galvanised pipes and fittings buried below ground surface shall be protected by wrapping petrolatum impregnated cloth tape around the full perimeter of the pipes and fittings to a distance of 100 mm above ground level.

PSL12.6 Cast Iron Covers and Frames

Cast iron covers and frames shall be painted with black epoxy-tar paint conforming to the requirements of SABS 801 Type 111 and shall be applied in two coats each with a dry film thickness of 250 micron.

PSL12.7 Mild Steel Lids and Frames (not galvanised)

Mild steel lids and frames shall be provided with two coats of epoxy paint to a total minimum dry film thickness of 250 micron, unless otherwise specified.

PSL13 CONSTRUCTION

PSL13.1 Pipe Cover

The minimum cover of the soffit of pipe couplings shall be 1 000 mm or as otherwise specified. The markings on pipes shall be visible from above after installation.

PSL13.2 Marker Blocks and Markers

Marker blocks and markers indicating the position of pipes and valves shall consist of precast sections of kerbs with a 100 mm high x 75 mm wide x 6 mm deep letter "W" (water main) and/or "V" (valve) recessed into the concrete during manufacture. In cases of existing kerbs, the letter shall be cut into the concrete in a clear legible mark or sandblasted with a template.

PSL14 MEASUREMENT AND PAYMENT

PSL14.1 Materials and Installation

The Contractor will be responsible for measuring the actual lengths of pipeline to be constructed and number of fittings to be installed prior to ordering of materials. Payments will be done for actual work done and materials installed and not in accordance with the quantities as scheduled.

PSL14.2 Jointing

No separate payments will be made for jointing materials and the cost thereof shall be deemed to be included in the rates Contracted for the material or component jointed unless specified otherwise.

PSL14.3 Corrosion Protection

No separate payment will be made for jointing materials and the cost thereof shall be deemed to be included in the rated Contracted for the materials to be corrosion protected.

PSL14.4 Marker Blocks and Markers

Markers shall be measured by number extra over the rate Contracted for kerb units.

D. PARTICULAR SPECIFICATIONS

The following Particular Specifications are included

PE : ELECTRICAL SPECIFICATIONS

PG : GENERATOR SPECIFICATION

PP : PUMP SPECIFICATIONS

PORTION C: PARTICULAR PROJECT SPECIFICATIONS

SECTION W: SOLAR HIGH MAST FOR LIGHTING OF THE RESERVOIR SITE

PSW 1. SOLAR LED FLOOD LIGHT HIGH MASTS LIGHTING

The solar LED high mast lighting shall consist of:-

- 150Watt LED high illumination LED flood lights
- 400W mono crystalline solar PV panels
- Top mounted battery box/cabinet manufactured from 3C12 steel with enclosure
- 5.1kWh lithium LifePO 48-100A batteries
- Solar maximum tracker (MPPT) charge controllers
- Control electronic-interconnecting wire/cables and module mounting structure, at
- a height of 20 meters above the ground
- 19m/20m high mast pole split in sections, with 2m stubby to be buried in the ground
- in a cemented foundation. 17m/18m mast above the ground.

The solar LED high mast shall be designed in accordance with following requirements: -

- Design life of solar high mast be in excess of 5 to 10 years
- LED Luminaire rating of IP66.
- Die casted durable lamp housing shall be robustly constructed, weatherproof, hail proof, corrosion proof and vandal resistant. It shall be grey in colour.
- Luminaire shall have an operating temperature of -20°C to 55°C. The diffuser lens must be manufactured with polymethyl methacrylate (PMMA). The lamp shall consist of a LED board arrangement with a warranty. Must submit an IEC 60598-1 or IEC 60598-2-3 certification.
- The IP66 ingress protection rating shall ensure that all components are protected against the ingress of dust and moisture, which leads to corrosion and premature

failure. All screws, bolts and metal parts shall be stainless steel and anti-corrosion treated material.

- LED flood light must have a minimum of 22000 lumens (provide supporting lighting simulation results).
- 400W high efficiency mono crystalline silicon solar PV panel with IEC / TUV certification.
- Lithium LifePO battery (48V 100A) with charge-discharge cycles between 3000-6000 with 10 to 15 design life cycle.
- Luminaire shall have a maximum power point tracker (MPPT) controller with a 96% charging efficiency.
- Luminaire weight 6kg per luminaire.
- Luminaire correlated colour temperature (CCT) shall be 5000K with a CRI of >70.
- Luminaire shall be supplied with a galvanized mounting bracket.
- IEC or TUV certification shall be provided for solar panels, lithium battery, and for solar controller.

PSW 2. PHOTOMETRIC REQUIREMENTS

Attach detailed calculations to confirm photometric results, to the tender document. Submit the photometric data based on measurements undertaken by an internationally certified lighting laboratory. The photometric report shall contain:

- Absolute candela values, at an ambient temperature of 24.5°C and humidity of 65.7%
- Description and photograph of the luminaire under test.
- Supply voltage and LED currents during testing.

Calculations shall be based on the following criteria:

- LED lumen depreciation of 80%
- Maintenance factor of 0.9 (allowing for a 10% light loss due to dirt on the protector surface).

PSW 3. SOLAR CONTROLLER UNIT

The solar controller unit shall have ff.

- Charging temperature at daytime shall be between 0°C to 60°C When temperatures goes below 0°C, the control system will automatically stop to protect the battery.
- When temperatures go higher than 0°C, Discharging temperature at night is between - 20°C to 60°C.

PSW 4. WARRANTY

- The bidder shall provide a warranty that the goods supplied under the contract are new, unused, of the most recent or current models and incorporate all recent improvements in design and materials. The bidder shall warrant that all goods supplied under this contract shall have no defect, arising from design, materials, or workmanship or from any act or omission of the supplier, that may develop under normal use of the supplied goods under prevailing site conditions.
- The bidder shall warrant that each luminaire supplied under the contract shall have a maximum lumen depreciation of not more than 10% of the original lumen output of the luminaire during the period of warranty.
- The warranty shall remain valid for fifty-four (54) months after the goods or any portion thereof as the case may be, have been delivered.
- The Contractor shall promptly notify the service provider in writing of any claims arising under this warranty.
- Upon receipt of such notice, the service provider shall, within the specified period and with all reasonable speed, repair or replace the defective goods or parts thereof, without costs to JW.
- If the service provider, having been notified, fails to remedy the defect(s) within the specified period, JW may proceed to take such remedial action as may be necessary, at the service provider's risk and expense and without prejudice to any other rights which JW may have against the service provider under the contract.
 - 6x 150W – 132000lm minimum requirements
 - 9x 150W –

PSW 5. SOLAR HIGH MAST POLE SPECIFICATIONS

The solar high mast pole shall be supplied in four sections with flanges at the end of each section to bolt together, to construct a single high mast design.

The total length of 19m/20m – 17m/18m

- 2m mounting stubby with dimensions of 273mm diameter
- 6m 273mm
- 6m 219mm
- 5m 177mm

PSW 5. CONSTRUCTION

- Poles shall be of tubular design with a minimum diameter at the base of 275mm (outer diameter) and constructed in four sections by means of flanges welded to the base of each section.
- The steel used in manufacture of poles shall comply with SABS spec 1431 Grade 355WA with minimum yield strength of 355MPa. Bidder to provide test and analysis certificates. No steel sections shall be less than 3mm wall thickness.
- All welding shall be carried out by coded welders only. Proof that all welders have been tested shall be provided on request.
- Bidder to advise about supply of K-Clamp

PSW 6. DIMENSIONS

- Pole dimensions 127/101/76mm – poles shall be tubular design.
- The poles shall be 19m long with a 2m stubby suitable for planting in the ground, giving a mounting height of 17m.
- The poles shall at the upper end have a diameter of 177mm at the smallest point at the top of the mast.
- Access opening complete with cover, not smaller than 230 x 90 to be provided 2000mm above ground level. To be secured by two 5-sided stainless steel hot dip galvanized allen screws and galvanised mounting / gland plate.
- Earthing.
- The high mast shall be provided with earthing straps and rod which shall be fastened to mast as a safety measure.

PSW 7. CORROSION PROTECTION

All parts of the pole and its associated parts shall be hot dip galvanized to SANS 121 ISO 1461 specifications. Contractor to provide an inspection certificate upon request from JW.

No welding, drilling, punching, bending or removal of burrs shall be carried out after

galvanizing.

PSW 8. SCOPE OF WORK

The scope of work shall include design, manufacture, supply, install and commission of solar LED high mast lighting system including five years comprehensive warranty maintenance in various clusters within JW.

PSW 9. COMPLETE SOLAR HIGH MAST

A complete solar high mast should comprise of the following:

- 9 X 80W LED high illumination luminaires with battery packs and solar panel.
- Minimum 57AH 12,8V Lithium battery packs built into the LED luminaires
- The luminaire shall have an 18V 100W high efficiency mono crystalline silicon solar panel.
- A minimum 20m high (above ground) steel pole capable of mounting all of the above-mentioned LED luminaires, batteries and can withstand the load.
- The successful service provider will be required to assess the identified project sites and provide a layout for the solar high masts.

PSW 10. SOLAR RECHARGEABLE BATTERY

The solar rechargeable battery shall have the following features:

- The battery should be at least 57AH at 12,8VDC lithium LifePO battery packs.
- Battery service Life shall be more than 2000 times, under normal conditions.
- Operate in temperatures of between -30°C and 60°C.
- Have a charged maintenance ability according to IEC standards.
- Be capable of rapid charging in 1 to 6 hours.
- Battery enclosure shall be secured by means of steel tamper-proof allen/hex bolts to minimize theft and vandalism.

PSW 11. SOLAR RECHARGEABLE BATTERY

The solar LED high mast luminaire shall have the following specifications and parameters:

- Photocell
- 10° to 45° tilt angle
- Power output – 150W
- Voltage 48VDC
- Voltage fluctuation – 10% of rated voltage
- IP rating of IP66
- Minimum luminous flux of 22000Lm
- Colour temperature of 5000K
- Mounting height of 17m / 18m
- Working temperatures -30°C to +60°C
- Lighting time of 7 days a week, 12 hours a day/nights
- High efficiency LED > 130 lumens/Watt (bidder to provide proof or evidence)
- Colour rendering index (CRI) of 70/80
- Working lifetime of 50000 hours at 80% lumen maint. (Bidder to provide proof or evidence confirming statistical correlation).
- Warranty period of 5 years

Submit a report for LEDs used in the luminaire, which shall include ff.:

- Measured LED junction temperature for a given test condition and extrapolated for an ambient temperature of 35°C.
- LED drive current.
- LED manufacturer data that clearly correlates LED junction temperature and LED drive current to lumen maintenance.
- Attach proof confirming that failure of one LED will not cause additional LED's to fail.
- Battery enclosure shall be secured by means of steel tamper-proof allen/hex bolts to minimize theft and vandalism.
- Controller must incorporate a temperature sensor which shall reduce the current to protect the LEDs at higher than rated ambient temperatures. The temperature sensor is not to switch off the LEDs at high temperatures.

PSW 12. MOUNTING POLE

The high mast pole to be designed in accordance to SANS 10225 under the ff. criteria and working loads:-

- Terrain category 3
- Design wind speed 40m/s
- Altitude 0m
- Horizontal and vertical deflections shall not exceed the requirements of SANS 10225.

The high mast pole shall be a galvanized steel pole with ff. minimum requirements

- At least 17m above ground level
- Strength of 500KN – withstand total weight of up to 5,000kg.
- Working load of 144km/h cross winds.
- Mechanical winch to hoist up the luminaires up and to lower them to a working height that is reachable for maintenance purposes.
- Brackets to be mounted underneath top mounted battery enclosure to support the 150W LED luminaires

PSW 13. BASE

The base shall consist of the following:

- 2600x2600x2000 steel foundation for concrete base.
- The high mast foundations shall be designed and constructed in accordance with SANS 10100 (Pt 1 & Pt 2) to withstand the forces imposed by the mast. The soil conditions and the soil bearing capacity shall be determined by a set of DCP tests for each individual mast. The results of these tests shall be recorded and placed in the project file for each high mast installation.
- The concrete cover of the reinforcing bars shall be not less than 50mm in all cases. The contractor shall provide evidence of the actual concrete cover achieved for the base and the plinth. The concrete shall have a design compressive strength of not less than 25 MPa after 28 days. The concrete strength of the base and the plinth shall be measured after 28 days by the Schmidt Hammer Test method for each foundation. The test results shall be recorded in the high mast project file.
- The plinth shall be designed to have a projection of not less than 300mm above nominal ground level after backfill compaction has been completed.

PSW 14. LIGHTNING CONDUCTOR

Each high mast shall be fitted with a lightning conductor spike at the top point of the luminaire. This spike shall be connected to the highmast earthing system. The steel high mast may be used as the earth path provided that a 70mm² flexible copper cable is installed at hinge point to ensure that electrical currents do not pass through the hinge joint. The high mast shall be connected to the earthing system by means of a 16mm diameter stud welded to the inside of the mast.

PSW 15. GEO TECHNICAL SURVEY

The contractor shall be responsible for determining the soil conditions for each high mast location. This information shall be to the satisfaction and approval of the JW to ensure design confidence.

PSW 16. PROCEDURES REGARDS EXISTING SERVICES AND EXCAVATIONS

- The contractor shall be required to take special care to locate existing services that would be affected by the installation of the high mast. The contractor will be responsible for the repair and reinstatement to any services damaged by them or any of their sub-contractors.
- In the event of damage occurring to any existing services, the contractor shall immediately notify JW and the owner of the service.
- All repairs to these services shall be to the satisfaction of the JW and the owner of the service.
- Penalties including consequential damage shall be levied at the sole discretion of JW for damage to existing services caused under the following circumstances.
- Damage due to unauthorized excavation
- Damage due to unauthorized blasting activities.

PSW 17. DESIGN FREEZE

Upon review and acceptance of drawing and calculations by JW the design of each highmast shall be fixed. No modifications, revisions, or changes shall be made to the design and drawings, after this date, without prior written application to JW. The application shall include full technical and commercial motivation for the changes.

PSW 18. THEFT AND VANDALISM

Battery Enclosure and Solar Panels shall be secured by means of steel tamper-proof allen/hex bolts to minimize theft and vandalism.

PSW 19. NORMATIVE REFERENCES

The following table contains provisions that, through reference in the text, constitute requirements of the specifications. At the time of publication, the editions indicated were valid.

All standards and specifications are subject to revision, and parties to agreements based on this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

SANS / NRS STANDARDS STANDARD DESCRIPTION

NRS 025 Photo Electric Control Units for Lighting (PECU)

ARP 035 Guidelines for the Installation and Maintenance of Street

Lighting

SANS 121 Hot dip galvanized coatings on fabricated iron and steel articles

SANS 1088 Luminaire entries and spigots

SANS 1200 A General

SANS 1200 C Site clearance

SANS 1200 D Earthworks

SANS 1200 G Concrete structural

SANS 1200 H Structural steelwork

SANS 1200 HC Corrosion protection of structural steelwork

SANS 1431 Weldable structural sheets

SANS 2001 – CS1 Construction works : Structural steel works

SANS 10100 The structural use of concrete (Part 1 and 2)

SANS 10162 The structural use of steel : The limit states design of hot rolled steelwork

SANS 10214 The design, fabrication and inspection of articles for hot dip galvanizing

SANS 10225 The design and construction of lighting masts

SANS 60529 Enclosure for electrical equipment (Classified according to degree of protection that the enclosure provides)

SANS 60598-2-3 Luminaires : Particular requirements for road and street lights luminaires

SANS 62305-3 Protection against lightning

PSW 20. PAYMENT ITEMS

PSW 20.1 Fixed-charge items for

Prepare site, Supply and install Solar High Mast lighting, including all civil, structural, electrical and mechanical installation Unit: Prov Sum

PSW 20.2 Overhead, charges and profit for fixed-charge item PSW 20.1

This item will be calculated as a percentage of PSW 20.1.....Unit: %

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

GENERAL

Materials and Workmanship

All materials and components used in the manufacture and fabrication of equipment to be supplied shall conform to SABS / ISO standards or original equipment manufacturer specifications and shall be new and of the best quality and class suitable for the purpose specified.

Design and Standardisation

All equipment shall be designed and installed to ensure the maximum possible continuity of service occurs, and to facilitate inspection, testing, maintenance, repair and cleaning. Components shall comprise readily obtainable standard items that are ex-local stock.

Environmental Conditions

The incidence of lightning storms during summer is relevant on the Highveld. Atmospheric temperatures vary from below freezing point to more than 40°C. Humidity can also be high and could cause appreciable condensation within equipment not suitably sealed or protected against these conditions. All equipment shall be adequately enclosed, protected, and capable of operating satisfactorily under these conditions.

Layout of Installation

It is imperative that Johannesburg Water maintains a robust modular RTU system. It must be easy to remove, replace and repair any modular unit without opening-up units. All IO, Radio, Power, surge protection and other sub-components shall be self-contained units which shall be easily removable. It shall be easy to expand IO, surge protection, and communication mediums to the RTU i.e. be modular / components.

The outstation must be built with both 20% spare analogues and termination capacity and be housed in Powder Coated cabined such as the Perano 204 for inside and 104 for outside

All wiring shall be contained within conduit or trunking or within metal enclosed equipment. When two or more parallel rows of terminal blocks are used, the clear space between the blocks shall be at least 120 mm.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Where two or more pieces of electrical equipment, in close proximity, have similar signal or supply conditions, the use of a junction box to group the tail cables shall be made in order that a common multi-core cable may be run to the control room.

Cable entries into outdoor junction boxes shall be bottom entry only.

Cables carrying 230 Vac (power or ON/OFF signals) may only be run on the same cable tray as analogue signal cables if the spacing between the cables is at least 100mm, or if individually and overall screened cables are used.

Low voltage signals and power/audio output signals may not be run in the same cable without the permission of JW ESM management.

LV cables shall be laid 600mm and HV cables 1000mm below general ground level. All cables in soil trenches shall be bedded in river sand or sifted ground (no clay) 75mm below and 75mm over the cables before backfilling of excavations.

Installation of Equipment

Equipment shall be mounted for maximum accessibility and visibility. Workmanship shall be of good quality and all cutting, drilling, welding, etc., shall be neatly done. Each completed installation, including supports, brackets and wiring shall present a clean, compact appearance. All fixing hardware for field mounted equipment shall be finished off free from burrs or jagged edges.

REMOTE TERMINAL UNIT (RTU) AND ASSOCIATED COMPONENTS / FUNCTIONS

RTU shall be an intelligent, modular unit capable of data acquisition, local data processing and control program execution. It shall monitor and control local equipment in a stand-alone mode as well as being an intelligent node in a distributed processing network. It shall be microprocessor based and allow software reconfiguration and optimisation to occur both on-site and remotely via communication channels. The RTU must be fully backward compatible with the current SSE Maestro 14-way (RTU) in order to operate on the same telemetry communication platform and support open protocol DNP3 as well.

Installation

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

To facilitate installation, maintenance and future expansion, all Input-Output (IO), Relay modules shall connect to the master processor module. The RTU shall be based on the newest RTU technology and shall also have advanced PLC functionality fully compliant to IEC standards.

The RTU system shall be of modular design. The various components such as CPU, IO Modules, Radios, Power Supplies, and so forth shall be individual components designed in such a way that the individual components can be tested individually and replaced individually.

The RTU shall be supplied and equipped with the number and type of IO points, that are fully compatible with the RTU, and as indicated in the Bill of Quantities / Pricing Schedule. Future expansion shall be possible by simply plugging in additional IO modules.

A RTU design with CPU, IO Modules, radios, surge protection and so forth all integrated in one unit shall NOT be acceptable. The RTU system shall be of a modular design.

RTU Communication mediums

Various communication ports shall be required at various sites. Both to communicate with local IED and backhaul communication to SCADA and peer-to-peer between devices. Refer to the BoQ / Pricing Schedule for the number of Ports required for this project.

Surge Protection

The RTU IOs need to interface with the existing surge protection units as manufactured previously by SSE in order to ensure standardization of the systems within Johannesburg Water occurs. If other suppliers surge protection products are to be used, then the need to be able to be exchangeable and compatible with the surge protection as used on other existing JW outstations in the system. Surge protection inside the telemetry cabinet is an eight channel unit and at the end point at the instrument a 2 channel unit. The earth Protection units must be grounded with earth spikes and have to be connected with bare copper earth wire

Labelling

All marking and labelling standards of Johannesburg Water shall be maintained. The tenderer may, on request, visit another site to view the layout and labelling standard.

Tag Readers / Biometrics

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Integrated in the existing telemetry system are Tag / Biometric readers that is used by JW's Engineers, Technicians, and others authorised users to identify themselves when working at the site. This reader must be compatible with and interface with the existing SCADA system for the operators to identify who is on site in the telemetry control room in real-time.

Change of Events

It is important that the system data gathering from the master shall not be primarily based on a round robin polling method, but primarily on Change of State (Eventing) basis. The remote station RTU shall have the ability to report change of state (event) of user configurable IOs. Thus, the remote RTU shall only initiate communication when a data change event occurred which shall be reported to the master station or peer-to-peer to other sites in the system. These event settings shall be user configurable using the Configuration Toolbox at the master station and be downloadable from the master or any other remote site. All events shall be remotely time stamped at the RTU when it occurred within 10 millisecond accuracy.

All Digital inputs dead times shall be individually configurable. Thus, the Engineer/Technicians shall be able to set re-action times on each input which shall trigger an event when such changes occur.

All Analogues input shall also be individually configurable. The sample timings, number of samples, and sampling triggers shall be configurable and downloadable to the remote station from the master station.

Remote Time Stamping

It is important that the remote RTU system supports remote time stamping of events as close as possible to the source of the event. Thus, the RTU Controller shall be equipped with a real-time clock and remotely time stamp all events, change of states and values. All events shall be time stamped within 2 milliseconds accuracy. These events shall then report the new value with the remote time stamp to the master SCADA station.

COMMUNICATION BACKBONE (DIGITAL RADIO)

The present GE based MDS digital radio platform is used on the existing telemetry outstations. To ensure backwards compatibility to existing communication networks, if new communication

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

equipment is to be offered then it shall be equal or similar to the GE- MDS Orbit Communication System Range.

All radio equipment to be used for the Telemetry System shall be fully ICASA approved. If an alternate to this brand is to be offered, then the tenderer needs to clearly demonstrate their solution in their proposal, and if required present a formal presentation to JW.

General UHF Radio Characteristics

- The device shall operate in the 450-520 MHz narrowband spectrum.
- The device shall support software-enabled frequency selection.
- The device shall support QPSK, 16QAM and 64QAM modulations.
- The device shall support channel sizes of 6.25 KHz, 12.5 KHz and 25 KHz.
- The device shall support Half Duplex/Simplex modes.
- The device shall support CPFSK Digital A-modem for backward-compatible mode connectivity to existing GE MDS SD Series radios.
- The Radio shall operate at over the air data rates from 9600 to 66 KB.sec.
- The radio shall be able to operate in Transparent Mode (Serial Streaming) to natively transport serial data. The radio shall be able to operate in the Packet-with-MAC mode to transport IP data.
- Small Sites - ECR
-

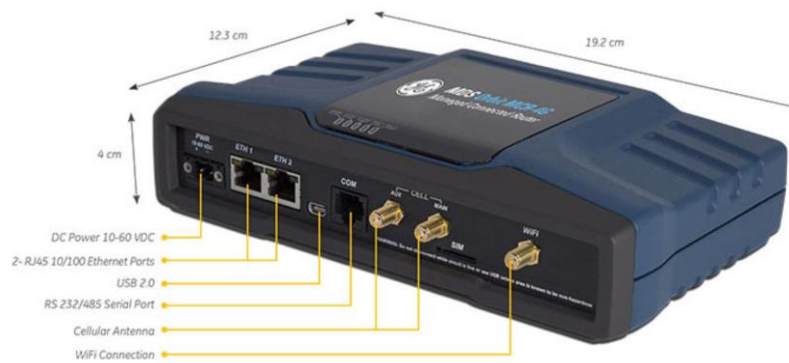
MDS Orbit ECR – An Exterior View



- Base Stations/ High Sites / Repeater sites – MCR

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)



Note: Only radio carrier equipment which is approved by the Independent Communications Authority of South Africa (ICASA) for use in the Republic of South Africa in terms of Radio Act, Act 3 of 1952, shall be offered. The contractor shall, on request, provide JW with a copy of the relevant certificate of approval. (Type approval certificate).

Outstation UHF Antennas

Antennas shall comply with the following:

- The outstation shall be equipped with type Webb HD400 heavy duty dipoles (omni directional unity gain antennas), or similar as approved by Johannesburg Water.
- Where higher gain or directionality is required, a 3 element or 7 element Yagi antenna or type Webb Y425/3 or WEB Y425/7 shall be used, or similar as approved by the System Development Manager (also referred to as the Engineer).
- If high a gain antenna is required, such would be indicated in the Price Schedules.
- Antenna earthing will be a “crow feet configuration “ with earth spics 2 meters apart.

Outstation Antenna Masts

- Where outside masts are required, antenna masts shall be similar and equivalent to a Webb ACP 50 / 3 / 5 and fitted to the side of the building with the necessary offset brackets and mounting hardware. These masts shall be earthed / surge protected.. It shall be attempted to mount antennas on the inside of the buildings as far as possible and in such a case, antennas shall be mounted on offset brackets on the inside of the pump station, or other available building.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- The antennas shall be supplied complete with mounting arms, clamps and support. All mounting materials shall be heavy duty galvanized steel or stainless steel or aluminium.

Smart Data Loggers

Johannesburg Water (JW) requires a range of Compact Robust Battery-Powered Data Loggers that are remotely downloadable and programmable (Smart) for primary use of logging: flow, level, pressure readings, in various combinations, on selected sites. The Contractor / Service Provider / Supplier may source the various remote (smart) data logger units and or transmitters (when required) from one or multiple manufacturers as long as the original equipment manufacturer (OEM) and or Agent of the products proposed are within South Africa.

NOTE: The Brand Name and Model / Part number of each product priced for shall be indicated next to the item when quoting and the relevant Datasheets or Operating Manuals included with the RFQ submission. This is to allow JW Technical Team the opportunity to evaluate the products offered to ensure they meet these Technical Specifications below.

Functionality of Remote (Smart) Data Logger

The Data Loggers shall be compatible with the following inputs in various Channel Combinations:

- Electronic or Mechanical **Pulse** sources with intelligent sensing window to eliminate relay bounce errors.
- **Analogue** input (pressure, level, flow) must be 4-20mA, isolated, 24V loop powered, with a sleep mode function for power conservation.
- **Modbus** Port (pressure, level, flow) must be RS485 (2-wire).

Data logger Channel Combinations required by JW:

- **Item 1: 2x Analogue + 1x Digital (Pulse) Remote Data Logger**
- **Item 2: 1x Analogue + 1x MODBUS Port Remote Data Logger**

These remote (smart) data loggers must be microprocessor based to allow reconfiguration and optimisation to occur. The remote data logger must support as a minimum of 4G (LTE) transmission and allow for Bluetooth programming on-site.

Power Supply of Remote (Smart) Data Logger

- The data logger units must by default be battery powered with internally housed batteries that may be replaced by JW personnel without affecting the product warranty. The data logger supplied batteries must provide a minimum of 2-years operation in standard

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

configuration i.e. 5 (five) minute logging intervals of all channels and 2 (two) data transmissions per day to a dedicated server, be it in the cloud and or on-premises.

- The data loggers shall be supplied (priced) to JW with the battery pack (unit) or batteries required to power the data logger unit included.
- Additional battery pack (unit) / batteries necessary to replace exhausted batteries of the data logger units later must readily be available for Johannesburg Water to procure themselves in the market and not be unique (proprietary) to the type of logger procured.
- The data logger units must also be able to connect to an external power supply: such as Solar PV or 12V DC with an auto changeover to the internal data logger battery when the external power source is insufficient / not available.

Communication / Protocol Technology of the Remote (Smart) Data Logger

- (UDP/IP) and or MQTT(S) connectivity must be supported, allowing connection to any JW server or SCADA system(s).
- Smart data logger units must support automatic real-time clock synchronization of the device with the cellular network for example.
- The modem used in the Remote (Smart) Data Logger units must be as a **minimum** 4G (LTE).
- The remote data logger units must be able to operate on any of the mobile network operators in South Africa who are registered with ICASA.
- Settings and firmware of the units must be updated remotely using the Product Portal, or locally via an embedded webserver.

Data logging interval

- Must be selectable by the user (JW) from typically 1 (one) minute update rate to 24-hours for the smart data logger units.

Data Transmission Interval and Data Storage

- When powered by battery or externally powered the transmission rate must be selectable from 1 (one) minute to 24-hour intervals and anything in between.
- If externally powered, then online streaming of data measurements must be achievable.
- Every measurement must date and time stamped.
- The data loggers must have a memory capacity of at least 100 000 sets of measurements.
- Johannesburg Water must be able to manage from the devices (remote data loggers) to the SQL servers themselves and that the data, that is downloaded on-premise or on cloud servers, must be owned / accessible / managed by the client, in this case JW.
- Should JW decide to discontinue using the remote (smart) data loggers for any reason, JW must be able to access, including report on, the historical data without the need of licensing with the OEM for the remote data logger, portal firmware and or software.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Access to the product portal / web-based scada for viewing data, remote setup and firmware upgrades must be factored into the price of each unit for a period of 3-years from the purchase date of the logger.
- All data transmission costs on an ICASA registered 4G (LTE) network must be included for 3-years in the purchase price of each smart data logger with no annual licensing fees (if applicable) during this same period.
- Any new product release notes and or software revisions must be made available to JW throughout the duration of the 3-year period.

Remote (Smart) Data Logger Housing

- Must be a minimum rating of IP67.
- The housing material must be UV stable and corrosion resistant.
- Must have a suitable handle to secure the data logger with a chain and padlock to a cat ladder or valve handle for example.
- Operating environment (minimum ranges): -10°C to 60°C. RH less than 85% non-condensing.

Remote (Smart) Data Logger Reporting

- Must be able to integrate seamlessly with a web-based SCADA and designated employees / users must be able to receive automatic (scheduled) emailed reports of flow, pressure, level or other parameters; daily flow totals; water balances etc.

INSTRUMENTATION / EQUIPMENT SPECIFICATION

Instrumentation

- Johannesburg Water makes use of a wide variety of instrumentation which are to connect to the telemetry, The list below is not exhaustive and only provided as guidance to what may be coupled at the outstation:
 - H2O (Hydrostatic) Pressure Transducer for Level
 - Pressure range 350 mbar to 2.5 barG (3.57mWG to 25mWG)
 - Proof pressure 2 x Full scale (FS)
 - Burst pressure 3 X FS
 - Current Output 4-20mA (2 wire)
 - Supply voltage 10-30Vd.c. (Sensitivity: 0.1%FS/Volt)
 - Max loop resistance (Vs-10) x 50 Ohm
 - Conductivity Probe / Capacitive Sensor for Overflow detection
 - Supply Level Conductivity Probe with Stainless Steel electrodes. Output NO/NC potential free (IP 67 rated) contact

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Radar Level sensors
 - Model: dBR8 and dBR16
 - Dimensions: Nominal 90mm diam x 130mm height (3.54in x 5.11in)
 - Weight: Nominal 1.1kg (2.4lbs)
 - Measurement range: dBR8: 8m (26ft); dBR16: 16m (52.5ft)
 - Frequency: V-band
 - Beam angle: 8°
 - Sensor body material: Valox 357U
 - Cable lengths: Standard: 5m, 10m, 20m or 30m (16.4ft, 32.8ft, 65.6ft or 98.4ft).
Optional: up to 150m (492ft) in
10m (32.8ft) increments
 - Maximum separation: 500m (1640ft)
 - Mounting connection: 1" BSP
- Level Switches
 - See conductivity probes
- Electronic Magnetic Flow meters
 - Where there is an inflow from Raw Water the flow meters will be EMF flow meters
- Ultrasonic Flow meters
 - Where there is an outflow to the system, then flow meters Ultrasonic Flow meters or Insertion probe meters can be used
- The exact installation positions for the instrumentations required will need to be determined off the drawings and also verified on site. The tenderer will engage with the Engineering Specialist Technicians (ESTs) of JW or the JW Systems Development Manager to ensure the quantity, types and parameters / technical specifications of the instruments or equipment to be procured are of the same accuracy and reliability of the existing instruments or better.

Warranty

The tenderer will be required to provide a back-to-back warranty to that of the supplier (OEM / Agent) for these instruments or equipment procured in this method. However, Instruments sourced through the contract must hold at least a twelve (12) month warranty.

OUTSTATION EARTHING & CABLING SPECIFICATION

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Outstation Earthing

- All outstations shall be earthed in accordance with the Standard Specification. Mast down conductors shall be 25 x 1.6mm galvanised steel.
- An earth bar with at least 5 connections will installed inside the telemetry hut and all earth wires will be connected to the earth bar including instrumentation , antenna, telemetry .
- An additional 10mm² copper cable shall be installed between Telemetry box and instrumentation junction boxes.

Outstation Cabling

- RF cabling shall be RG214 or similar. All cabling shall be neatly run inside the masts and be supported with UV stable cable ties.
- All I/O wiring at the outstation shall be done with screened twisted pair wiring of 0,5mm² minimum, conductor area. Single core wiring shall not be used. All wiring to be neatly routed in plastic slotted ducting with snap on covers. All wiring shall be marked and numbered to correspond with the information on as-built drawings, to be prepared as part of this Contract.
- Tenderers shall allow for a 5m length of ducting, in their price calculations.
- It can be assumed that the existing I/O status outputs shall be made available on a marked terminal strip, within 5m of the telemetry outstation position. Wiring between these terminals and the outstation terminals, shall form part of this contract.
- All instrumentation cable shall be 12 Core multi strain 0.5mm oval screened with extra neutral wire. Lugs / Ferrules on all cables and all cables shall be clearly marked as per drawing. All surface conduits, fittings and bends shall be at least 20mm galvanized.

Trenching

- All trenches shall be at least 400mm deep, with a minimum of two off 50mm sleeving.
- A bare copper cable will be installed outside the sleeving with earth spikes on both ends
- Not more than 3 cables per sleeve is permitted.
- Instrumentation cable and power cable higher than 24V are not allowed in the same sleeve.
- All sleeves must have at least one draw wire per sleeve.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Every 20-25 metres there shall be a cable inspection box
- Only soft sand on cable, no rocks in trenches.
- Cable indicators on cable.

Cable Numbering and Marking

- The Contractor shall produce a cable schedule from which all cable identification numbers shall be derived.
- Cables shall be labelled with the cable number at the origin and destination points and at entries/exits to racking/ducting/penetrations, by means of a label, approved by the Systems Development Manager, suitably attached to the cable.
- The cable marking label shall be finished with a “fit-for-purpose” plastic sleeve, approved by the Systems Development Manager, suitably attached to the cable

Field Boxes Numbering and Marking

- The Contractor shall produce a “junction box / panel schedule” from where all field-mounted box identification numbers shall be derived.
- Field boxes shall be identified by means of an engraved label.
- Environmental suitable label holders shall be used such that labels can be removed without damage to the box.
- Attachment of label holders shall not degrade the IP rating of the box
- The box identification plate shall specify, where applicable, the following:
 - Panel Number
 - Equipment / Panel Service
 - Network / Control Systems Unique Identification

Cable Core Marking

- A wire marking systems shall be used to identify all cables cores at both ends in accordance with the wiring diagrams

Screening and Earthing

- Sensors cable screen conductors, used for grounding unwanted signal noise, shall be terminated to an isolated signal earth bar (instrument earth) located in the PLC /

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Control / MCC Panel or Remote IO Panels. An isolated earth bar is an earth bar that is isolated from the safety earth and connected to generation origin earth.

- Individual and overall screen wires of all sensors cables shall be terminated at the equipment room side only and shall be left disconnected (floating) and insulated at the instrument in the field.
- All single pair cable screen conductors shall be insulated and tied back at the sensor.
- Analogue single pair cable screen conductors shall be connected to individual terminals in a junction box.
- Overall analogue cable screen conductors and digital cable screen shall be insulated and tied back inside the junction box.
- Under no circumstances shall the screen conductors be utilised for any other purposes than for noise immunity.
- The safety earth (or electrical earth) shall be utilised for the safety earthing of all metal automation equipment and supports.

Field Mounted Boxes

- All C&I panel's degree of protection shall be suitable for environmental conditions of installation according to IEC 529 and EN 60529 (1991). Control / PLC / MCC panels shall be epoxy coated mild steel or other material as dictated by the installation environmental conditions and specifications.
- Door handle shall be suitable for padlocking.
- The box shall be numbered.
- All digital signal wiring shall be SABS Approved stranded, minimum 0.75mm, 200V grade PVC insulated conductors.
- All power wiring, including neutral wiring shall be SABS approved stranded, minimum 1mm, 600v grade PVC insulated copper conductors.
- All data wiring shall be SABS approved stranded, minimum 0.22mm, tinned copper cores, twisted pair, screened cable.
- All analogue signal wiring shall be SABS approved stranded, minimum 0.75mm, 200V grade PVC insulated tinned copper cores, twisted pair, screened cable.
- DC Power shall be fused on the positive leg by appropriate fuse.
- AC Power shall be circuit breaker protected on Live and Neutral legs
- All Conductor Terminal blocks/rails shall be clearly identified

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Notwithstanding the above, the cross-sectional area of all wiring cores shall be calculated to “fit-for purpose”.
- All wires shall be supported in PVC trunking to hold all conductors running horizontally and vertically, Trunking shall be sized so that it is at no stage more than 80% full.
- Where wires travel from fixed to moveable locations, for example from a chassis to a hinged door, the wires shall be bunched together and harnessed by PVC spiral wrapping or braided polyamide sleeving. Harnesses shall be secured on the fixed and moveable section.
- Conductors shall be connected by means of single terminal connector blocks only.
- Double / Triple stack terminal connector build-form shall not be used.
- No ferruled, taped or similar joints shall be made in connecting any conductors.
- Cable and wire marking systems shall be used to identify all cable cores at both ends in accordance with the wiring diagrams. The markers shall be white with black. The markers shall fit securely, without sliding, over the cable core insulation.
- Where cable cores pass through metal holes, suitable non-flammable grommets shall be provided.
- Only crimped connector/lugs shall be used. Soldered lugs shall not be accepted. Crimping tools shall be of a type approved by the connector/lug manufacturer.
- DIN rail mounted components shall be used wherever possible.
- All components shall be so fixed that they may be removed and replace without the aid of special tools. Only fasteners with metric threads shall be used.
- Lightweight components shall be mounted on the chassis plate by means of holes directly drilled and tapped into the chassis. Galvanised or cadmium plated steel screws shall be used.
- Heavyweight components shall be mounted on the chassis plait or cubicle framework either by means of studs welded direct to the chassis or frame, or by means of suitable self-gripping hand bushes with cadmium plated nuts and washers.
- Care shall be taken to ensure that instruments and components are rigidly supported and not susceptible to shock or vibration

Cables and Cable Cores

- All cables shall comply with the relevant SANS specification for the cable application.
- Outer insulation material of cables for in confined spaces shall be fire retardant, non-toxic and Halogen free.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- All cables shall be tested prior to delivery to site. The tests shall establish that the cables dielectric is sound, that all cores are continuous from end to end, and it complies with the cables schedule details and manufacture specifications.
- The cross-sectional area of all cables cores shall be calculated to be “fit for purpose”.
- Unused or spare cables cores shall be strapped together with cable straps should they not be connected to spare terminals.
- The length of spares cores shall exceed the length of the longest used core.
- Consistency in the use of core colours and/or numbers shall be maintained throughout the installation to avoid confusion.
- Colour and/or number coding of cores shall be shown on the relevant drawings.
- Cores passing through holes in chassis or screens shall be fully protected by fitted grommets or bushes.
- Cores carried across a hinged portion of a chassis or door shall be flexible. Sufficient slack shall be provided to obviate tension.
- The insulation of a core shall not be stripped back further than or less than necessary. The conductor shall not be exposed with a crimped insulated terminal lug fitted.
- Not more than one core shall be connected to one side of a connection terminal block.
- Core terminations shall be fitted with interlocking engraved (black letters on white background) plastic cable ferrules, reference numbered to correspond with the related schematic or wiring diagrams. Split or clip-on ferrules or adhesive marking tapes are not acceptable. The marking for horizontal runs shall be from left to right when facing them, and for vertical runs from the bottom upwards.
- The wiring inside panels and junction boxes shall be well planned and neatly arranged in the best possible manner, allowing for forming of cores so that there is no strain on them

Signal Cable Installation

- Cables shall be installed neatly, either saddled or strapped to the panel or supporting steelwork. Where there is not possible or practical, the cable loom shall be strapped together using proprietary type plastic cable available for this purpose. Cotton insulation or thread shall not be used.
- Cables shall be secured and connected at terminations to prevent undue mechanical stresses upon glands, conductors or terminals.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Signal and communication cables shall be segregated and separated from power cables on separate racking, parallel routes shall be separated by a minimum distance of at least 300mm, space permitting and if physically possible.
- Cables shall not be installed double banked on racks.
- Armoured cables shall be secured to racks or angle-iron supports by 10mm wide stainless-steel strapping and purpose-made buckles.
- Unarmoured cables shall be secured to racks or supports by fit for purpose PVC or nylon.
- The span of strapping shall be such as to prevent bunching of cables, and in any event, should not exceed 1000mm
- Cables running horizontally on cable racks mounted vertically(edgewise)shall be secured to cables racks at 60mm intervals, which shall be reduced as necessary to prevent unsightly sagging of cables.
- Cables laid flat in racks parallel with a slightly inclined ground or floor surfaces need not be secured to the racks more often than is necessary to prevent cables from moving because of expansion, contraction or vibration.
- Any horizontal or vertical cable run that are not strapped or supported in such a way that the cable cannot fall in the event of fire shall be strapped by 10mm wide stainless-steel strapping and purposes-made buckles at 1 metre intervals.
- Holes for cables passing through panel steelwork shall be made smooth or bushed to prevent severing of the cable and fitted with appropriate grommets.
- Joints in cable are prohibited unless the route lengths exceed the maximum lengths the manufacturer can supply. In this eventually, approved proprietary types of junction boxes shall be used. Joints shall only be used the approval from the Employer.
- When stripping insulation from cores, the conductors shall not be nicked or cut.
- All conductors shall be terminated in an insulated double crimped termination lug of the correct size using a crimping tool approved by the manufacturer of the terminal.
- Bare conductor terminations shall not be accepted.
- Pin lugs shall be used for connections using terminal strips and spade lugs when terminating under a screw head.
- Holes into air-conditioned rooms shall be completely sealed off to maintain the air conditioning system performance.

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

- Cables screens at the unearthed end of the cable are to be tied back and covered with heat shrink sleeve. Cable screens shall not be cut off at the cable sheath.
- Cables shall enter an enclosure from the bottom and shall be formed to relieve stress on the cable end, with a sealing boot fitted over the cable gland.
- Cables to instruments shall be terminated in a locally mounted approved IP65 connection box with a short length of flexible cable with a single 150mm diameter loop strapped to a suitably supported angle iron.
- The connection box can be multiple-way units to accommodate more than one loop, provided the loops are associated. A terminal strip shall be fitted inside the box for core connections
- Sealing boots shall cover the cable glands fitted to connection boxes.
-

SCADA

- Define Tags (I/O)
- Create I/O in OPC and SCADA
- Create Programs in OPC
- Graphic Forms a per JHB Specifications
- Faceplates
- Generator Graphic Forms and interface
- Logging to SQL
- Trending
- Alarming
- ASI- reports
- Data Warehousing\
- Detail Mimics
- Region Mimic
- Update Script programs
- Detail Maps
- Overview Mimics

I/O List

Housekeeping Digitals

Mains Failed	DIN
Telemetry Hut Door 01 Alarm	DIN
Telemetry Tamper Alarm	DIN
Tower Door Alarm	DIN
Solar Door Alarm	DIN
Solar Tamper	DIN
Intruder Alarm Enable/Disabled	DIN
Passive Detector	DIN

Housekeeping Analogs

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Battery Voltage 12V	AIN
Battery Voltage 24V	AIN
Solar Voltage 240 V	AIN

Reservoir

Digitals

Reservoir Overflow	DIN
--------------------	-----

Counters

Reservoir Inflow Counter	CIN
Reservoir Outflow Counter	CIN

Analogs

Reservoir Level 01 Submersible	AIN
Reservoir Level 01 Radar	AIN
Reservoir Level 01 Data Logger	AIN
Reservoir Level 01 Inflow R1-In-01	AIN
Reservoir Level 01 Outflow R1-Out-01	AIN

Tower

Digitals

Tower Overflow	DIN
----------------	-----

Counters

Tower Inflow Counter	CIN
Tower Outflow Counter	CIN

Analogs

Tower Level 01 Submersible	AIN
Tower Level 01 Radar	AIN
Tower Level 01 Data Logger	AIN
Tower Level 01 Inflow R1-In-01	AIN
Tower Level 01 Outflow R1-Out-01	AIN

Pump Station

Digitals

Pump station Door	DIN
Pump station Flood Alarm	DIN
Pump station Pump 01 Run (Hard Wired)	DIN
Pump station Pump 01 Trip (Hard Wired)	DIN
Pump station Pump 01 Auto/ Man (Hard Wired)	DIN

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Pump station Pump 01 Emergency Stop (Hard Wired)	DIN
Pump station Pump 02 Run (Hard Wired)	DIN
Pump station Pump 02 Trip (Hard Wired)	DIN
Pump station Pump 02 Auto/ Man (Hard Wired)	DIN
Pump station Pump 2 Emergency Stop (Hard Wired)	DIN

Analogs

Pump station Suction Pressure	AIN
Pump station Delivery Pressure	AIN

Note : The above exclude all modbus signals from the PLC and the VSD . A list to be send with available signals to chose from and what EMD would like to see

Generator Interface

- **Deepsea**
 - **Dse 8610 / 7320**

Synchronising & Load Sharing Control Module

- **Digitals**

Fail to start 9 (Hard Wired)	DIN
Trip (Hard Wired)	DIN
Emergency Stop (Hard Wired)	DIN
Fuel Low (Hard Wired)	DIN

Note : The above exclude all modbus signals from the Interface board . A list to be send with available signals to chose from and what EMD would like to see for example:

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)



BOQ Telemetry Outstation

TELEMETRY OUTSTATION BASED ON 16 DIN /16 AIN / 16 DOU				
ITEM	Telemetry Panel	QTY	Unit Price	Total Price
1.1	DIN rail mounted Power Supply 10A 12 V	1		R0.00
1.2	Maestro 2500 CPU12 With ASC1 14 Way	1		R0.00
1.3	Maestro 8-Multi I/O Module 14 Way	1		R0.00
1.4	RS 232 Multiplexer 8 Channel	1		R0.00
1.5	ICP Con 485 Convertor	2		R0.00
1.6	8 Channel Differential input without battery monitoring	2		R0.00
1.7	Surge Protection non-isolated 8 channel	1		R0.00
1.8	8-way buffer unit	1		R0.00
1.9	Fused Power Distribution Board	1		R0.00
2.0	12V DC to 24V DC Converter unit 5A	1		R0.00
2.1	220VAC Mains Surge Arrestor	1		R0.00
2.2	220V Circuit Breaker	1		R0.00
2.3	Intruder Switch (MICRO SWITCH LOW TORQUE WIRE LEVER 1C/O 5A)	1		R0.00
2.4	Perano Enclosure 205G – Indoor	1		R0.00
2.5	GE MDS Orbit ECR radio (406-470 MHz)	1		R0.00
2.6	Panel Manufacturing and testing	1		R0.00
	Junction box consists of	QTY		QTY
2.1	Perano Enclosure 204G – Indoor	1		R0.00
2.2	Panel build up and testing	1		R0.00
	Battery box consists of	QTY		QTY
3.1	Perano Enclosure 204G – Indoor	1		R0.00
3.2	Lithium Battery 100AH 12V	1		R0.00
3.3	Panel build up and testing	1		R0.00

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Access control consists of		QTY		QTY
4.1	Tag Reader (TRD A3)	1		R0.00
4.2	PIR (Microwave and infrared)	1		R0.00
4.3	Siren 2 Hole Sound Bomb	1		R0.00
4.4	Magnetic door switch	1		R0.00
4.5	Sundries (cable, cable tray)	1		R0.00
	Antenna kit consists of	QTY		QTY
5.1	Folded Dipole UHF 440MHz HD 440	1		R0.00
5.2	Coax Pigtail RG58, 0.5m, TNC Male to N-Type Male	1		R0.00
5.3	Foam Low Loss - LMR400 (meters)	1		R0.00
5.4	RF Connectors N-Type Male	2		R0.00
5.5	Lipro N Type Surge Bracket Included	1		R0.00
5.6	Wall Mount Bracket - WM45	1		R0.00
5.7	Galvanized mast 50mm x 2mm x 6m	1		R0.00
5.8	Comprehensive Earth Kit (20mx70mm ² , 10mx10mm ² , 5x1.2m Spikes, 5 off Earth Clamp & Lugs)	1		R0.00
5.9	Earth Bar 300mm with 5 Holes and brass Bolts and Nuts	1		R0.00
5.1	Sundries (cable, cable tray, rawl bolts)	1		R0.00
	Preliminary & General consists of	QTY		QTY
6.1	Project Management (hours)	16		R0.00
6.2	Installation Labour (hours)	24		R0.00
6.3	Test & Commission (hours)	8		R0.00
6.4	Travel	500		R0.00
6.5	SCADA and OPC configuration and commissioning (hours)	48		R0.00
6.6	SCADA / Alarm Management configuration a(hours)	48		R0.00
6.7	SCADA and Reporting and commissioning (hours)	48		R0.00
6.8	Drawings and Documentation / Manuals	48		R0.00
			TOTAL	

BOQ PV SOLAR INVERTER WITH BATTERY BANK

Item	Description	Units	QTY	Unit Price	Total Price
1	Main Solar Distribution Board				
1.1	3CR12 Powder Coated Distribution Board Including AC & DC DBs	No.	1	R0.00	R -
1.2	Compatible with Sunsynk 5kVA Inverter	No.	1	R0.00	R -

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

1.3	125A 2P DC Fuse Holder & 125Amp Fuses	No.	1	R0.00	R	-
1.4	Solar panel larger or equal to 450W	No.	8	R0.00	R	-
1.5	Stand for Solar Panel Mounting on top of Reservoir (Anti-theft)	Sum	1	R0.00	R	-
1.6	5kWH C1 Rated Lithium Batteries (Rackmount)	No.	2	R0.00	R	-
2	Telemetry Hut Distribution Board (230V)					
2.1	Industrial Type Surface Distribution Board 12-way	No.	1	R0.00	R	-
3	Bunker					
3.1	Outdoor Vandal Resistant Steel Enclosure	No.	1	R0.00	R	-
3.2	Complete Chassis	Sum	1	R0.00	R	-
3.3	24v DC Power Supply	No.	1	R0.00	R	-
3.4	DC Surge Arrestor	No.	8	R0.00	R	-
3.5	Signal Surge Arrestors	No.	4	R0.00	R	-
4	Cables & wires					
4.1	KBE Solar cable 6mm ² red	m	25	R0.00	R	-
4.2	KBE Solar cable 6mm ² black	m	25	R0.00	R	-
4.3	10mm ² x 3 core Cu PVC SWA Cable (Telemetry Hut)	m	180	R0.00	R	-
4.4	4mm ² x 3 core Cu PVC SWA Cable (Guard House)	m	100	R0.00	R	-
4.5	2.5mm ² x 3 core Cu PVC SWA PVC cable (Clamp on Flow Meter)	m	50	R0.00	R	-
4.6	1mm ² x 1pr Cu PVC SWA Cable (Clamp on Flow Meter)	m	50	R0.00	R	-
4.7	2.5mm ² x 3 core Cu PVC SWA PVC cable (Magflow Flow Meter)	m	50	R0.00	R	-
4.8	1mm ² x 1pr Cu PVC SWA Cable (Magflow Flow Meter)	m	50	R0.00	R	-
4.9	1mm ² x 2pr Cu PVC SWA Cable (Hydrostatic Level Transmitter)	m	120	R0.00	R	-
4.10	1mm ² x 2pr Cu PVC SWA Cable (Radar Level Transmitter)	m	120	R0.00	R	-
4.11	1mm ² x 16pr Cu PVC SWA Cable	m	155	R0.00	R	-
5	Cable ends					
5.1	KBE Solar cable 6mm ² red MC4	No.	4	R0.00	R	-
5.2	KBE Solar cable 6mm ² black MC4	No.	4	R0.00	R	-
5.3	10mm ² x 3 core Cu PVC SWA PVC cable	No.	2	R0.00	R	-
5.4	4mm ² x 3 core Cu PVC SWA PVC cable	No.	2	R0.00	R	-
5.5	2.5mm ² x 3 core Cu PVC SWA PVC cable	No.	4	R0.00	R	-
5.6	1mm ² x 1pr Cu PVC SWA Cable	No.	6	R0.00	R	-
5.7	1mm ² x 2pr Cu PVC SWA Cable	No.	12	R0.00	R	-
5.8	1mm ² x 16pr Cu PVC SWA Cable	No.	12	R0.00	R	-
6	Small power & Lighting					
6.1	22W LED Vapourproof Light Fittings equal and similar to C10 Lascon	No.	2	R0.00	R	-
6.2	34W LED Bulkhead Light Fitting equal and similar to B40-Lascon	No.	7	R0.00	R	-

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

6.3	USB phone charger	No.	1	R0.00	R	-
6.4	Industrial light switch and enclosure to Johannesburg Water Specification	No.	3	R0.00	R	-
6.5	Light point	No.	10	R0.00	R	-
6.6	Light switch point	No.	3	R0.00	R	-
6.7	Phone charger point	No.	1	R0.00	R	-
6.8	20w LED flood light on reservoir	No.	1	R0.00	R	-
7	INSTRUMENTATION					
7.1	Hydrostatic level	No.	1	R0.00	R	-
7.2	Radar level transmitter	No.	1	R0.00	R	-
7.3	Clamp on flow meter	No.	1	R0.00	R	-
7.4	Magflow flow meter meter	No.	1	R0.00	R	-
7.5	Vented radar level sensor support system	No.	1	R0.00	R	-
8	TELEMETRY					
8.1	Radio System equal and similar to Johannesburg Water Specification	Sum	1	R0.00	R	-
10	CABLE SUPPORTS					
10.1	100mm Galvanised Pipe with Hanger Bolts	m	12	R0.00	R	-
10.2	25mm² gals. conduit	m	32	R0.00	R	-
10.3	25mm² gals. Hospital saddles	No.	32	R0.00	R	-
10.4	25mm² gals. Round Boxes	No.	12	R0.00	R	-
11	EXCAVATION					
11.1	Pickable Soil	m³	80	R0.00	R	-
11.2	Soft Rock	m³	20	R0.00	R	-
11.3	Hard Rock	m³	10	R0.00	R	-
11.4	Importation of Soil	m³	30	R0.00	R	-
11.5	Cable Beneath Tape	m	50	R0.00	R	-
11.6	Cable Route Markers	No.	20	R0.00	R	-
12	CORE DRILLING					
12.1	110mm Hole	No.	1	R0.00	R	-
13	MISCELLANEOUS					
13.1	CCG Boxes No.0	No.	12	R0.00	R	-
13.2	24V Power Supply Unit	No.	1	R0.00	R	-
13.3	Fuses and Fuse Holder	No.	2	R0.00	R	-
16	P+G's					
16.10	Fixed					
16.11	Contractual Obligations	Sum	1	R0.00	R	-
16.12	Manuals	Sum	1	R0.00	R	-
16.20	Time Related					
16.21	Contractual Obligations	Sum	1	R0.00	R	-
16.22	Travel	Sum	1	R0.00	R	-
16.23	Company Overhead Costs	Sum	1	R0.00	R	-

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

16.24	OSHA	Sum	1	R0.00	R	-
17.0	Commissioning	Sum	1	R0.00	R	-
18.0	Certificate of Compliance	Sum	1	R0.00	R	-
	Total				R	-

Solar Hybrid Inverter Specification

Model	SYNK-3.6K-SG03LP1		SYNK-5K-SG03LP1
Battery Input Data			
Battery Type	Lead-acid or Li-Ion		
Battery Voltage Range	48Vd.c (40Vd.c ~ 60Vd.c)		
Max. Charging/Discharging Current	90Ad.c (max.)	120Ad.c (max.)	
Charging Curve	3 Stages / Equalization		
External Temperature Sensor	Yes		
Charging Strategy for Li-Ion Battery	Self-adaption to BMS		
PV String Input Data			
Max. DC Input Power	4680W	6500W	
PV Input Voltage	370V (125V~500V)		
MPPT Range	150~425V		
Full Load DC Voltage Range	300~425V		
Start-up Voltage	125V		
PV Input Current	13Ad.c + 13Ad.c		
No. of MPPT Trackers	2		
No. of Strings Per MPPT Tracker	1+1		
AC Output Data			
Rated AC Output and UPS Power	3600W	5000W	
Max. AC Output Power	3960W	5500W	
Peak Power(off grid)	2 times of rated power, 10s		
AC Output Rated Current	16.4/15.7Aa.c	22.7/21.7Aa.c	
Max. AC Current	18/17.2Aa.c	25/23.9Aa.c	
Max. Continuous AC Passthrough	35A		
Power Factor	0.8 leading to 0.8 lagging		
Output Frequency and Voltage	50/60Hz; 220/230 (single phase)		
Grid Type	Single Phase		
Total Harmonic Distortion (THD)	<3% (of nominal power)		
DC current injection	<0.5% In		
Efficiency			
Max. Efficiency	97.60%		
Euro Efficiency	96.50%		
MPPT Efficiency	>99%		
Protection			
PV Input Lightning Protection	Integrated		
Anti-islanding Protection	Integrated		
PV String Input Reverse Polarity Protection	Integrated		
Insulation Resistor Detection	Integrated		
Residual Current Monitoring Unit	Integrated		
Output Over Current Protection	Integrated		
Output Shorted Protection	Integrated		
Surge Protection	DC Type II / AC Type II		
Over Voltage Category	DC Type II / AC Type III		

Model	SYNK-3.6K-SG03LP1	SYNK-5K-SG03LP1
Certifications and Standards		
Grid Regulation	VDE4105, IEC61727/62116, VDE0126, AS4777.2, CEI 0 21, EN50549-1, G98, G99, C10-11, UNE217002, NBR16149/NBR16150	
EMC/Safety Regulation	IEC/EN 62109-1, IEC/EN 62109-2, IEC/EN 61000-6-1, IEC/EN 61000-6-2, IEC/EN 61000-6-3, IEC/EN 61000-6-4	
General Data		
Operating Temperature Range	-40~60 °C, >45 °C Derating	
Cooling	Smart cooling	
Noise	<30 dB	
Communication with BMS	RS485; CAN	
Weight	20.5kg	
Cabinet size	330W×580H×232D mm (Excluding connectors and brackets)	
Protection Degree	IP65	
Installation Style	Wall-mounted	
Warranty	5 years	

Solar Hybrid Inverter Specification

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

FEATURES



- **Longer Cycle Life** - Offers up to 20 times longer cycle life & 5 times longer calendar life than lead acid batteries, minimizing replacement cost.



- **Superior Safety** - Lithium Iron Phosphate chemistry eliminates explosion risk or combustion due to high impact, overcharging or short circuit situation. First life battery.



- **Higher usable capacity** - Delivers high power, while maintaining cycling of double energy capacity of lead acid battery.



- **Wider Temperature Range** - $-20^{\circ}\text{C} \sim 60^{\circ}\text{C}$.



- **Lighter Weight** - About 40% of the weight of a comparable lead acid battery. A 'drop in replacement' for lead acid batteries.



- **Multi-protocol communication** - Multiple protocols that can be selected via PC with an included RS232 cable.



Solar/wind
Energy Storage



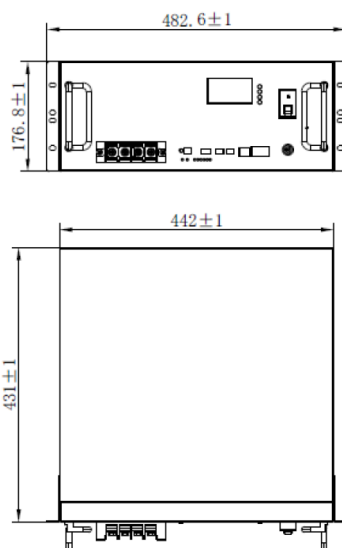
Caravan
power



Power
tools



Backup power for
UPS systems



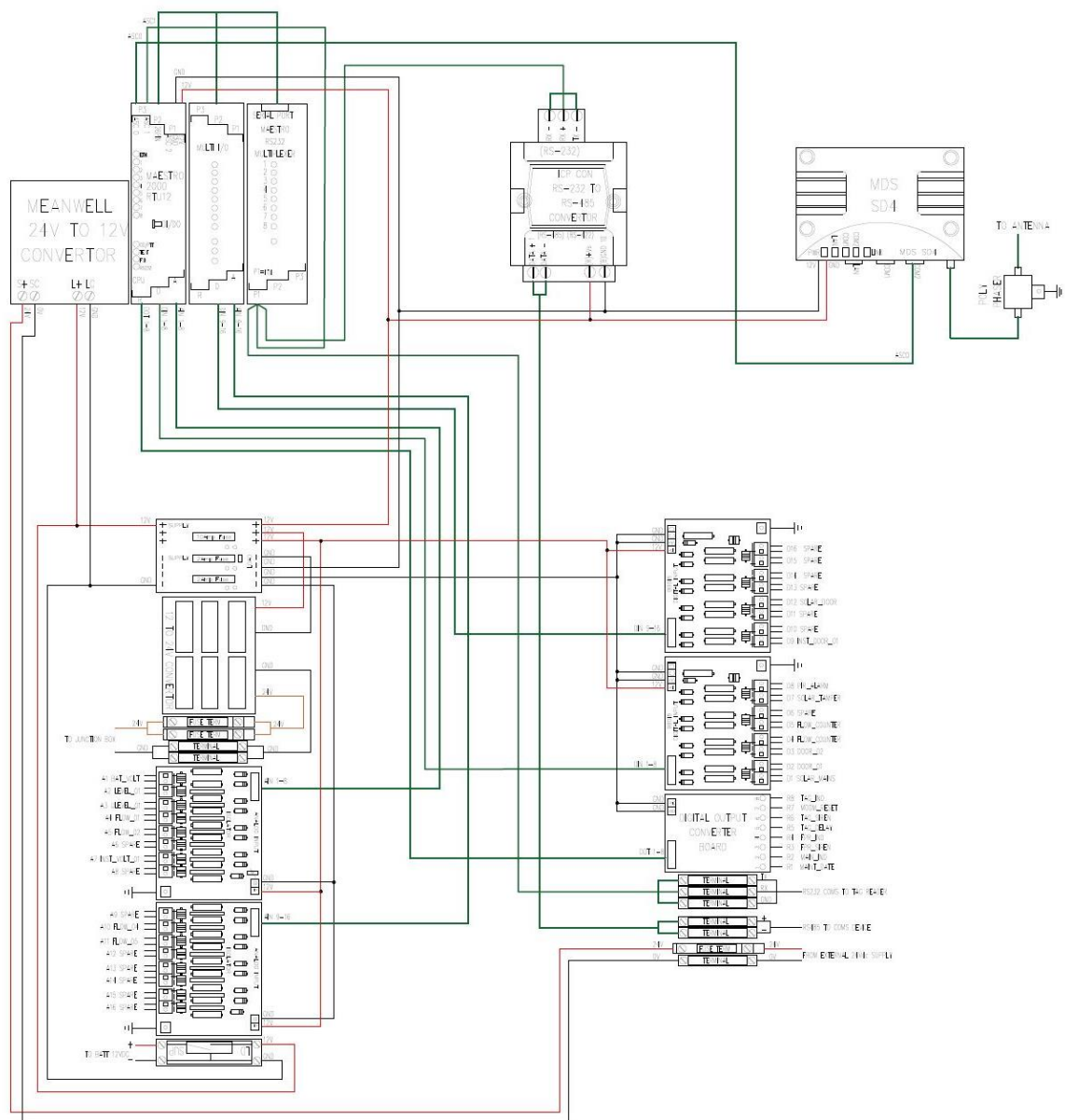
Model:	LFeLi 48100S2
Nominal voltage:	51.2V
Nominal Capacity:	100Ah
Energy:	5120Wh
Voltage range:	48~55V (limit: 45~57.6V)
Internal resistance:	<50mΩ
Cycle life:	>3500 cycles @ 100% DOD 25 °C
Self discharge per month:	<3%
Charge voltage:	57V (±0.6V)
Charge current:	Recommended 20~50A
Max Discharge current:	100A Continuous (120-130A Pulse) [1C]
Communication:	CAN or R485 (+RS232 to USB)
Temperature Range:	-20~60 °C

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Drawings

Telemetry Cabinet Wiring Diagram



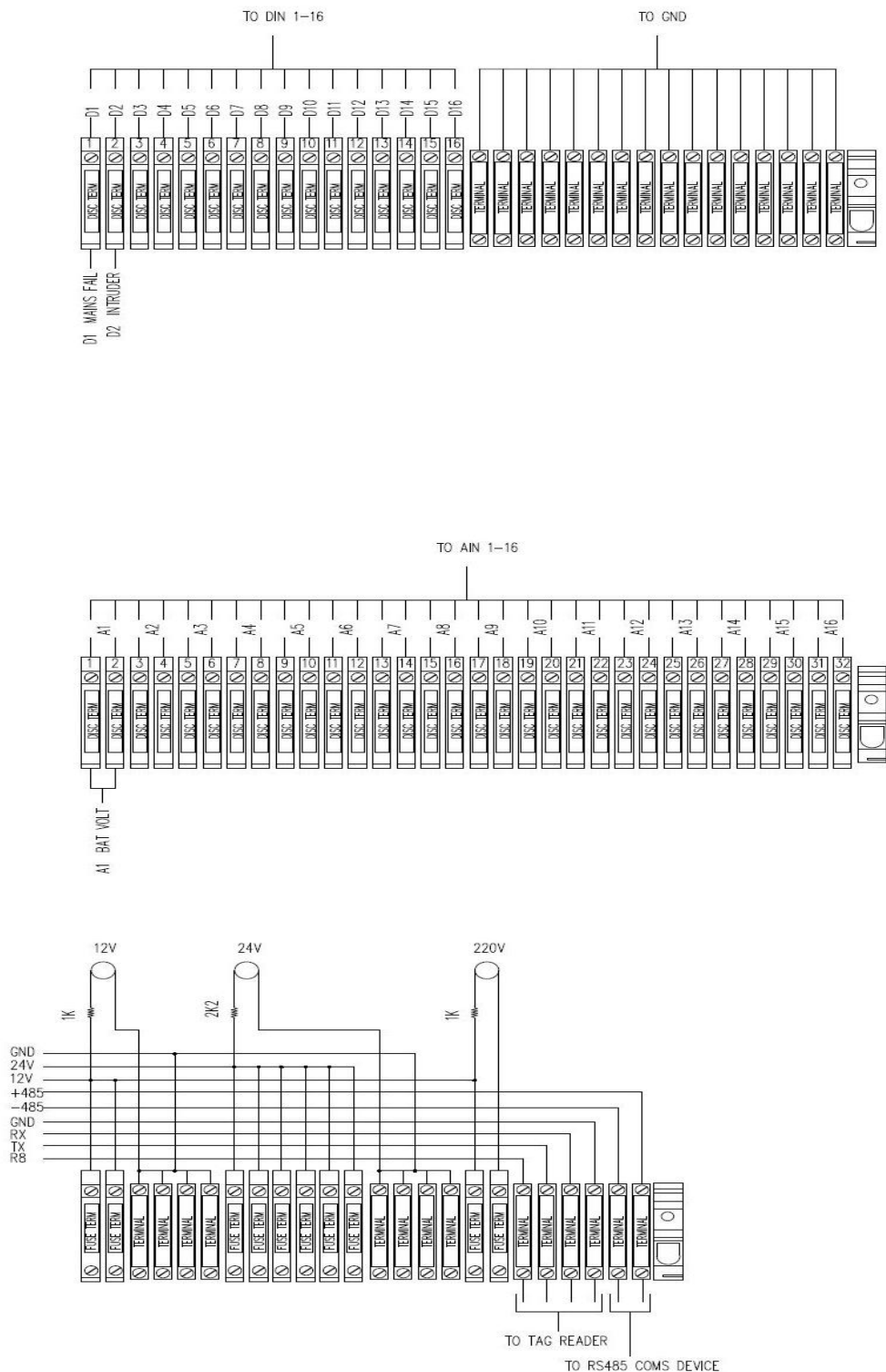
TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Telemetry Cabinet Wiring Diagram

TECHNICAL SPECIFICATIONS

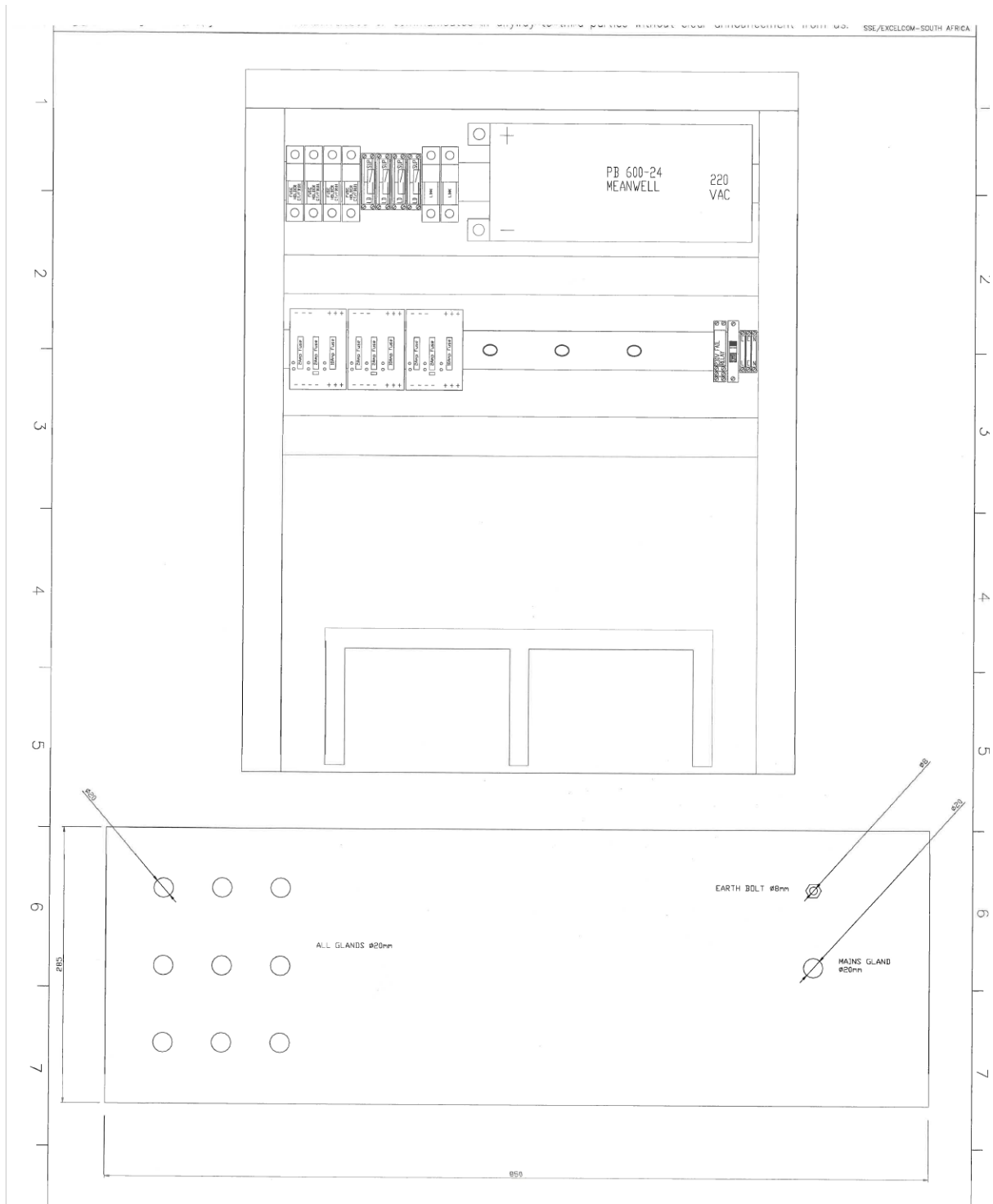
TYPICAL TELEMETRY OUTSTATION (UHF RADIO)



Batthey Box 24 V

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

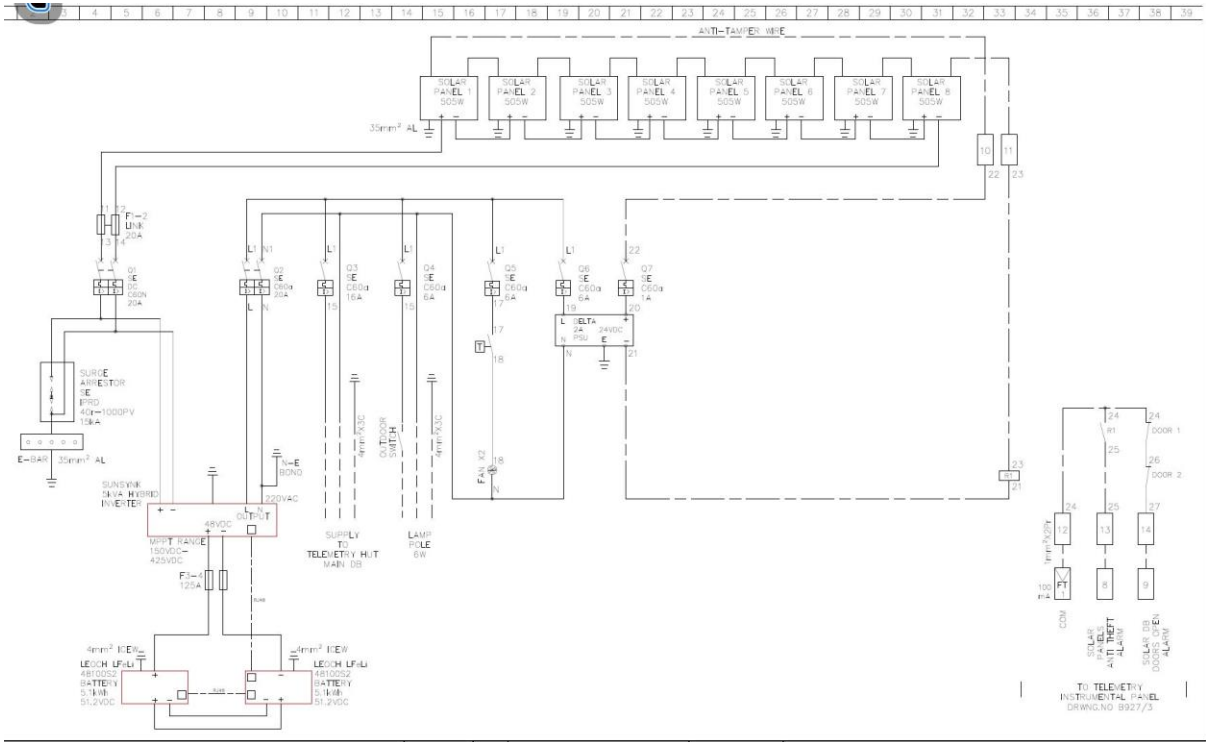


TELEMETRY HUT

SOLAR Drawings

TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)



NOTES:

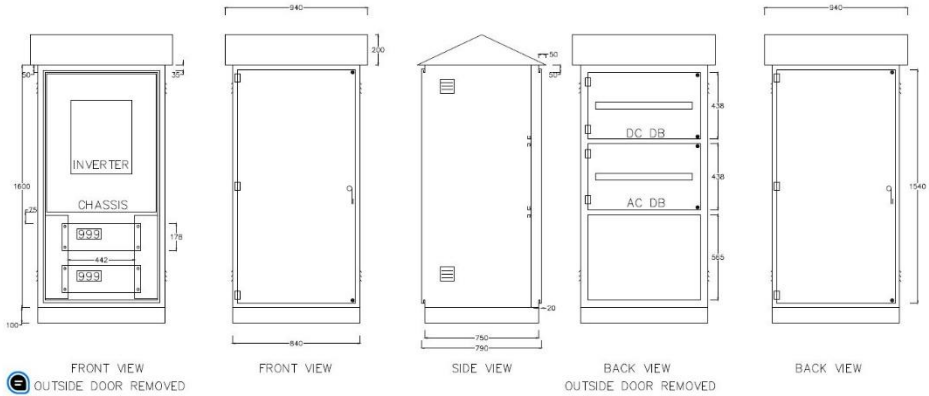
TYPE:
OUTDOOR FLOOR STANDING

MATERIAL:
304/2
IP54

COLOUR:
GREY

CABLE ENTRY:
BOTTOM

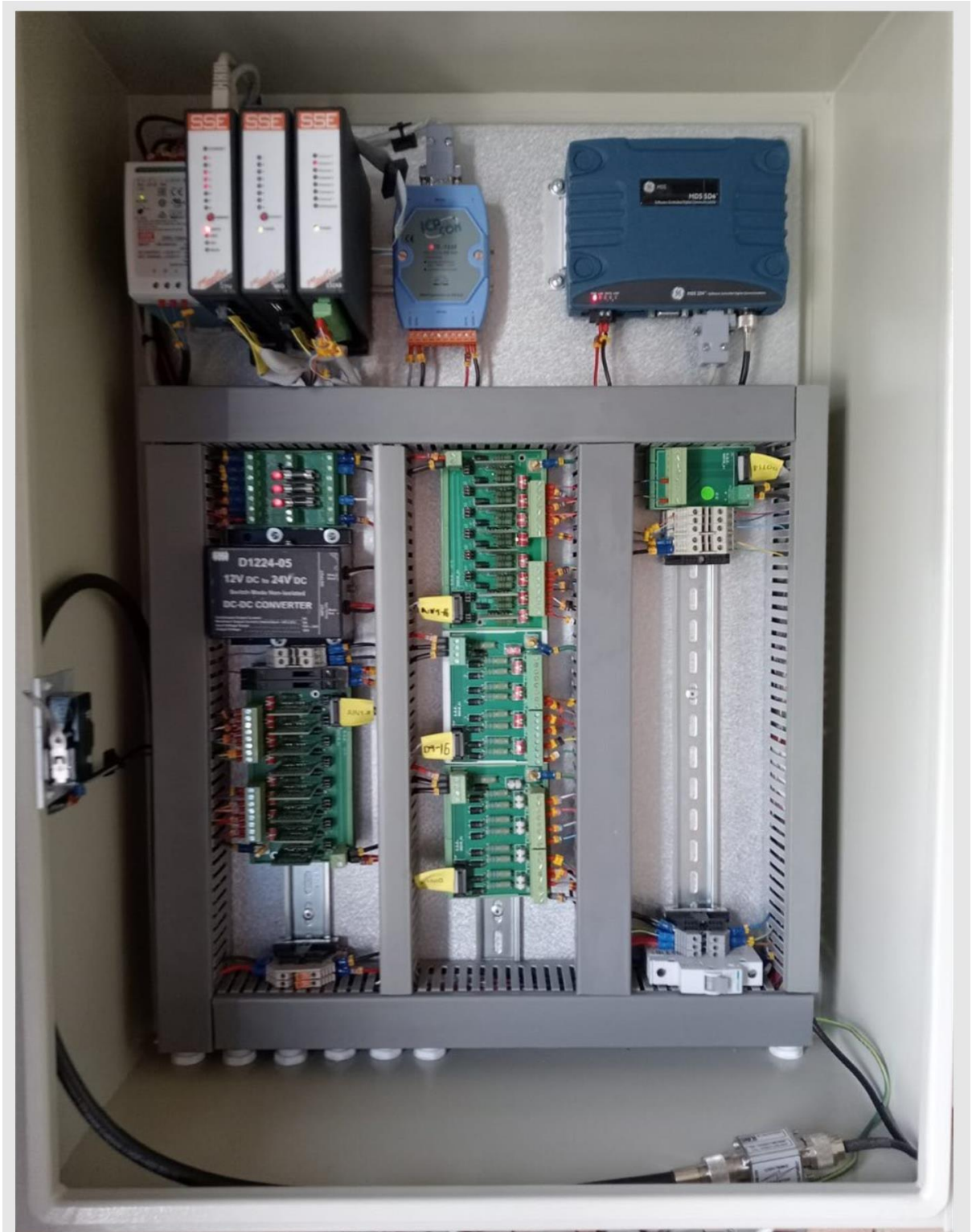
LEGEND



TECHNICAL SPECIFICATIONS

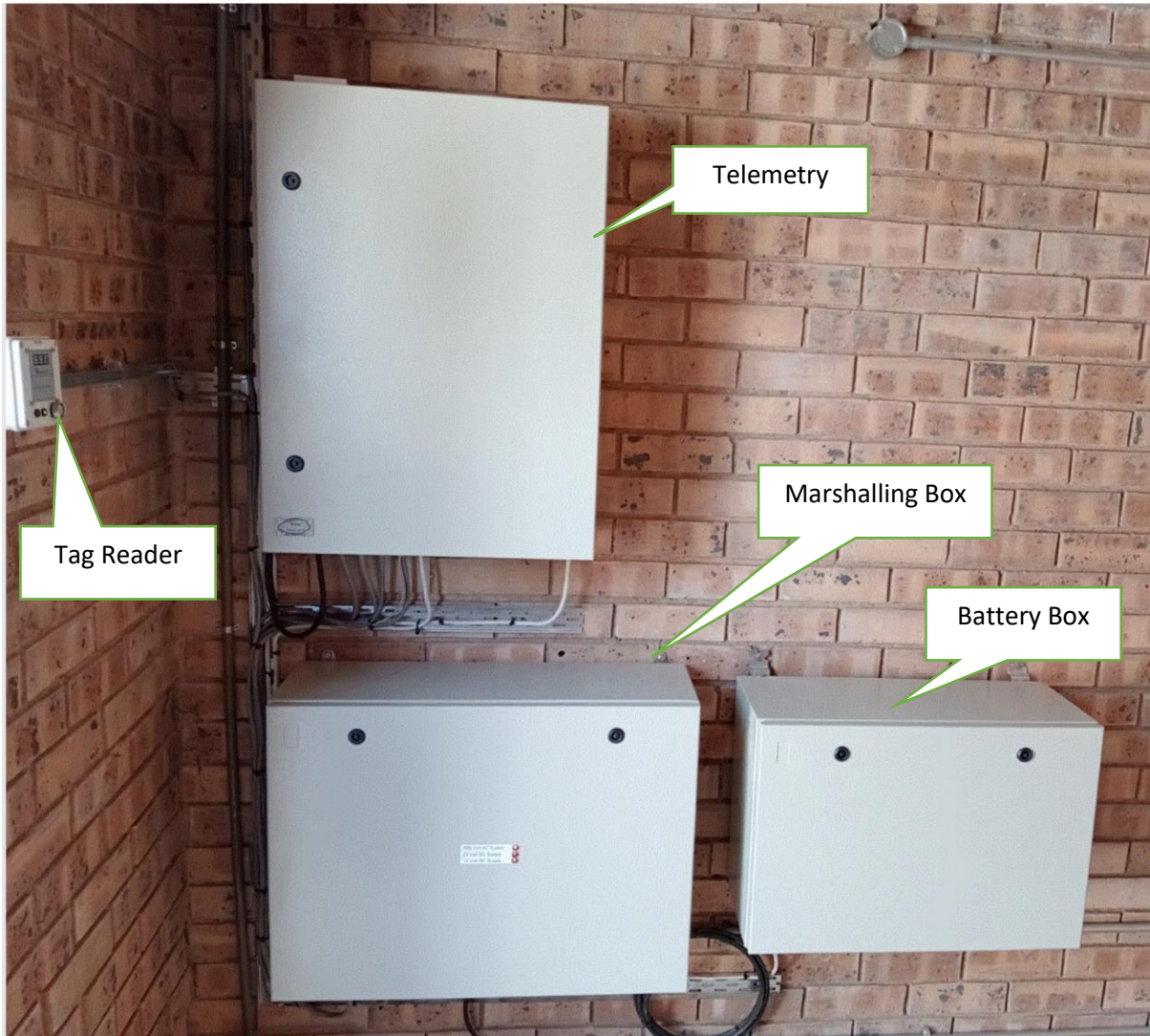
TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

Telemetry Enclosure



TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)



TECHNICAL SPECIFICATIONS

TYPICAL TELEMETRY OUTSTATION (UHF RADIO)

BATTERY BOX

