BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 1

GENERAL

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SECTION 1
GENERAL

1.1 PREAMBLE AND SCOPE

1.1.1 Format of TCTA Modular Standards

The TCTA Modular Standards form part of the Specification in terms of the FIDIC Conditions of Contract for Construction for Building and Engineering Works Designed by the Employer (Red Book) and the Employer's Requirements in terms of the of FIDIC Conditions of Contract for Plant and Design Build for Electrical and Mechanical Plant, and Building and Engineering Works, Designed by the Contractor (Yellow Book). The Modular Standards are aligned with the required provisions of the FIDIC Conditions of Contract, together with the Particular Conditions of Contract.

The different modules of the Standards are referred to as Sections which should not be confused with Sections of the Works referred to in the Conditions of Contract. Sections of the Modular Standards are identified with a unique number as follows:

MSX: where MS is Modular Standard and X is the number of the Section.

For example, the "Survey and Setting Out" Section of the Modular Standards has the following reference number:

Electronic file name: MS5 – Survey and Setting Out. It reflects Modular Standard Section 5

The Table of Contents reflects further subdivisions of Modular Standard Sections, for example:

The Survey of Ground Profiles is covered under Clause 5.7 and the Original Ground Profiles is covered under Sub-clause 5.7.1. All further subdivisions are referred to as Sub-clauses.

1.1.2 Specification versus Employers Requirements

The definition of the terms Specification and Employer's Requirements are detailed in the Conditions of Contract. Without prejudice to these definitions, the Specification is essentially a construction specification for Employer designed aspects of the Works, whilst Employer's Requirements are a performance specification for those aspects of the Works designed by the Contractor.

The Modular Standards are supplemented by the following project specific specifications in the Contract:

a) Specification for the Employer design aspects; and
b) Employer's Requirements for the Contractor design aspects.

1.1.3 Scope

Section 1 – General basically covers:

a) General standard specifications not covered in other Sections;
b) Site Facilities;
c) Programming requirements;
d) Construction matters and records; and
e) Drawings and correspondence

1.2 ABBREVIATIONS AND REFERENCES

1.2.1 Abbreviations

AIA	:	Approved Inspection Authority
BRVAS	:	Berg River Voëlvlei Augmentation Scheme
CMS	:	Construction Method Statement
DFFE	:	Department of Forestry, Fisheries and Environment
EIA	:	Environmental Impact Assessment
EA	:	Environmental Authorisation by DFFE
EMPr	:	Environmental Management Programme
MMS	:	Management Method Statement
OH&S	:	Occupational Health and Safety
QCP	:	Quality Control Plan
RFC	:	Ready for Commissioning
RFO	:	Ready for Operation
RFPC	:	Ready for Pre-Commissioning
RFTO	:	Ready for Trial Operation
TCTA	:	Trans-Caledon Tunnel Authority
UPS	:	Uninterruptable Power Supply

1.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

1.3 USE OF THE SITE

1.3.1 General

The Contractor shall not use the Site for any purpose other than that of executing the Works or for any purpose other than as designated under the Contract and shall confine his operations to within these areas unless otherwise approved by the Engineer.

The Contractor shall arrange for and comply with all current legislation and its regulations that are relevant to the Site and use thereof. Such may be classified use of land, erection and use of facilities such as explosive magazines, disposal of waste, and others.

1.3.2 Temporary Fencing

As part of Temporary Works, the Contractor shall erect fencing on all boundaries of the Site as specified in Section 6. Fencing shall be erected by the Contractor prior to commencing any other operation or work and maintained by him for the duration of the Contract. The Contractor will not be permitted to work or perform any operation prior to completion of such fencing and will not be allowed to continue with operations should the fencing be damaged or fall into disrepair, until the fencing has been repaired. Security fencing is required at the Facilities for the Employer, Engineer and Contractor and all storage areas and stock proof fencing at all other areas, except that game proof fencing is required on properties with game.

1.3.3 Ownership of Existing Structures and Equipment

All existing structures or equipment on the Site that are to be demolished and/or removed in terms of the Contract shall become the property of the Contractor unless otherwise indicated by the Engineer. All other existing structures, services or related ancillary structures on the Site, insofar as they may be the property of private landowners or others or the Employer, shall remain the property of those landowners or others or the Employer and, except as and to the extent required elsewhere in the Contract, shall not be interfered with by the Contractor in any way. When working in proximity to existing structures, the Contractor shall comply with Construction Regulation 11 - Structures. When demolishing any structures the Contractor shall comply with Construction Regulation 14 - Demolitions.

1.3.4 Existing Rights of Way

Any existing rights of way or roads running through the Site shall be diverted around the Site or fenced off in such a way as to prevent unauthorised persons from inadvertently entering the Site. Such rights of way or roads shall be kept open at all times except for short periods when construction activities such as surface blasting could require closure for safety reasons.

The Contractor shall make arrangements to allow essential continued access for local residents, subject to the review of the Engineer.

1.3.5 Construction Establishment Areas

Construction establishment areas comprise of:

- Construction camp area for temporary offices, laboratories, workshops, store buildings and related facilities; and
- Construction storage or laydown area/yards for outside storage of construction material, pipes, etc.

The Contractor shall prepare a site establishment plan for the review of the Engineer prior to establishment on Site. This plan shall identify construction activities, facilities and structures with due consideration of sensitive environmental features. The planning process shall also take the following aspects into account:

a) Locate construction camps in areas approved as part of the EIA and EA process.
b) Facilities and structures shall be located with due cognisance of the terrain and geographical features of the project site.
c) Positioning of the storage and lay-down areas should aim to minimise visual impacts.
d) Control the movement of all vehicles and Equipment (including suppliers), such that they remain on designated routes and comply with relevant agreements.
e) Minimise public disturbance from lighting of the construction camp and site. For example, proper design of the placing (zones), height, type, direction (inward rather than outward) and intensity of floodlights, without compromising safety.

The Employer will not provide any services at these locations and will not be responsible for the availability or non-availability of additional establishment areas nor for facilities at any establishment areas. It is the Contractor responsibility to ensure any establishment area complies with all the relevant legislation, ordinances, and bylaws.

When no longer required, the Contractor shall rehabilitate the relevant area in accordance with the requirements of Section 47 – Landscaping and Rehabilitation.

1.4 CONSTRUCTION FACILITIES PROVIDED BY OTHERS

The Employer will not provide any construction facilities and the Contractor shall be responsible for all required facilities and to arrange with authorities and other owners where applicable, and for any charges raised by the relevant authorities and owners for services or facilities.

The Contractor shall also be responsible for any licenses, approvals and the like required by relevant authorities for the use of any infrastructure or services during construction. The Contractor shall comply with Facilities Regulation 1 to 9 when establishing on Site.

1.5 FACILITIES PROVIDED BY THE CONTRACTOR FOR THE ENGINEER

1.5.1 General

The Contractor shall provide, erect and maintain the Engineer's facilities as specified for the sole use of the Engineer's Personnel and Employer's Personnel. The facilities shall be available from the date any of the construction activities commence.

The Engineer's main Site offices with related facilities and services shall be established at the same location as the Contractor's main Site offices.

All offices, facilities and equipment shall be new and be furnished, serviced, cleaned and maintained by the Contractor.

The Contractor shall provide the necessary firefighting equipment.

Standby energy power and water shall be provided.

All areas within the Engineer's Site Office perimeter area fence not covered by buildings, carports or access road shall be grassed. The grass shall be cut and watered regularly to maintain a clean and dust free area. The grass shall be of a non-invasive indigenous type.

The Contractor shall keep the facilities clean and shall provide adequate cleaning staff for this purpose throughout the Contract period.

The Contractor shall be responsible for all running costs and costs for other services, including telecommunication, electricity, water, etc. to operate and maintain the offices efficiently. The Contractor shall provide all consumables required for the facilities.

The Contractor will remain the owner (or renter) of the facilities and shall be responsible for the insurance thereof.

The Contractor shall dismantle and remove from the Site all facilities provided which are no longer required, as agreed by the Engineer, and shall rehabilitate all affected areas in accordance with Section 47 - Landscaping and Rehabilitation.

1.5.2 Engineer's Offices

Each office complex, including car parking, shall be fenced with 2,1m high razor mesh wire including razor flat wrap on top with a double leaf, vehicular access lockable gate. A suitable guardhouse shall be constructed at the entrance to the complex which shall also include ablution facilities.

The layout of the Engineer's facilities shall be submitted for approval by the Engineer prior to commencement of its construction. In this respect, the Contractor shall submit fully dimensioned drawings together with a project specification for the construction.

The buildings for the Engineer shall be single storey, weatherproof, rodent- and termite-proof, dust proof and burglar proof. Burglar proofing shall at a minimum include burglar bars in front of all opening windows as well as fixed panes. Buildings shall be constructed of treated timber, fibre-cement, brick, concrete block or other durable materials. Prefabricated buildings shall have double walls filled with insulating material and lined on the inside with suitable material. External walls of brick or concrete block shall be of cavity construction. All walls shall have a fire rating of at least 60 minutes and maximum thermal conductivity of 2.1 W/m².°C.

All opening windows shall be fitted with mesh flyscreens. All external doors shall be of exterior quality and fitted with a five lever mortice lock. Interior doors shall be fitted with three lever locks with keys. Two keys shall be supplied for each lock. In addition, 2 master keys that fit all locks shall be provided. All external doors shall have “slamlock” type grill gates.

Thermally insulated ceilings (insulation 70 mm thick glass fibre matt or equivalent, total maximum conductivity of 0.6 W/m².°C) shall be provided throughout and the floor shall be damp-proofed concrete raised at least 225 mm above the highest adjacent external ground level.

The floors of brick office buildings, including the entrance hall, store rooms, change rooms, kitchens and ablution facilities shall at a minimum be smooth float finished screed with Vinyl tiles. The minimum clear height between floor and ceiling shall be 2.4 m.

The document storage and server rooms and doors shall have a fire rating of 240 minutes and be burglar proof as described above. The plan printing/photocopier and UPS rooms shall each be fitted with extractor devices to remove noxious fumes.

One wall of the kitchen is to be equipped with upper and lower cabinetwork including a double bowl/ double drain board stainless steel sink.

Each building shall have fully glazed windows each at least 30% opening for ventilation. Total window area for each room shall be at least 20% of floor area.

Roofing to all buildings shall be hail-proof, at a minimum pitch of 15°.

Each room/office except the kitchen shall be provided with a reverse-cycle air conditioner so that a temperature range of 18-25°C can be maintained throughout. In addition to the above, a minimum of one reverse-cycle air conditioner per 15 m² or part thereof shall be provided for larger rooms.

Hot (55°C) and cold running water (potable standard) shall be provided to the kitchen, showers and wash basins and cold running water only to toilets. Hot water pipes shall be lagged or otherwise suitably insulated.

The electrical system shall comprise a 60 A three phase 380/220 V 50 Hz supply which shall be connected to a mains isolator in the building's distribution board.

Circuit breakers of adequate rating shall be provided for the following circuits in the non-essential supply side of the distribution board:

- Lighting; and
- Switched socket outlets connected to 30 mA earth leakage units.

On the essential supply side of the distribution board (15 kVA uninterruptable power supply), 10 A single pole circuit breakers shall be provided for every two computer switched socket outlets.

Each office shall be provided with three switched socket outlet units. Two switched socket outlet units shall be fed from the non-essential supply and the other from the essential supply side of the distribution board. The essential supply socket outlet units shall have a flat side on the earth pin socket to prevent appliances other than computers from being connected to the uninterruptable power supply. Open plan office areas and the boardroom/conference room shall be equipped with four switched socket outlet units (two from the non-essential supply and the other two from the essential supply) per 10 m².

Lights shall be of the fluorescent type with suitable diffusers, either double 80 W or triple 65 W to offices and either single 80 W or double 65 W to ablution facilities and passages. A minimum of one such light per 15 m^2 of floor areas or part thereof shall be provided. External lighting shall be sufficient to provide adequate lighting between offices and carports. This lighting shall be switched by photo electric cell or equivalent.

The Contractor shall provide a fully functional and working computer network, including all networking equipment like switches and routers (Industrial type, fanless) as well as networking software, cabling (Cat 5e or 6 – UTP or STP) and connections (RJ45) to the following requirements:

- Two working internet/e-mail data connection points each per office;
- One working internet/e-mail data connection point each for reception offices;
- Two working internet/e-mail data connection point each per conference room; and
- Two internet/e-mail data connection point for each 10 m^2 open plan office area.

All power, computer network cabling and telephone cabling shall be contained in accessible split trunking power skirting at floor level. Power cabling and the computer-and-telephone cabling shall be used separately.

The floor of the passage connecting each office or building shall be constructed of concrete and be at least 1.2 m wide. The passage shall also be covered at roof level with metal sheeting.

The road from the access road to the Site Office area and the carports shall consist of a layer of concrete or shall be block paved.

1.5.3 Engineer's Access to Site Laboratories

The Site laboratory shall be available for the Engineer on a shared basis.

1.5.3.1 Car Ports

Car ports shall be constructed over specified parking areas so that the vehicles parked under them will at all times be protected against the direct rays of the sun and protected from hail.

The car ports shall each be at least 20 m^2 in area and the floors shall consist of 75 mm concrete or paving blocks or a suitable layer of broken stone, to alleviate dusty and muddy conditions. Each carport shall be at least 3 m wide and shall have headroom of at least 2.2 m. The roofs of all car ports shall be of corrosion protected metal sheeting. Carports shall be clearly numbered.

The Contractor shall provide the covered carports adjacent to the offices detailed above and shall establish adequate security arrangements, to the satisfaction of the Engineer, to guard against theft and vandalism.

The Contractor shall provide and maintain a paved vehicle wash bay complete with labour, water connection and garden hose and fitments suitable for the purpose of washing vehicles at the main construction establishment

1.5.4 Engineer’s Facilities after Completion of the Works

Following issuing of the Taking-Over Certificate for the Works, the Contractor shall provide, maintain and service one large (4 m x 4 m) office with related necessary ablution facilities and services. The office will be required for a period of three months for the use of the Engineer while completing administrative tasks and to settle the final accounts.

1.5.5 Assistants for the Engineer

The Contractor shall make available to the Engineer the assistants as detailed in the Specifications or Employer’s Requirements.

The Contractor shall supply all pegs and concrete, together with the necessary labour for excavations, mixing and placing, as and when required by the Engineer.

These assistants shall be screened, employed and paid by the Contractor and shall be provided from the Commencement Date until the date of the last Taking-Over Certificate. The whole of the

time of such assistants shall be at the Engineer's disposal and when called upon to do so shall assist the Engineer on other work concerned with the project. Such assistants shall not be replaced without the approval of the Engineer. The Contractor shall provide an immediate replacement for any assistant who, in the sole discretion of the Engineer, is unsatisfactory.

1.5.6 Medical

The Contractor shall make all the first aid facilities established for his own staff continuously available to the Engineer's Personnel and Employer's Personnel and authorised visitors, provided that any such use shall conform to the normal controls and regulations that the Contractor applies to his own staff. The Contractor shall comply with General Safety Regulation 3.

1.5.7 Fire Control

Each building shall be supplied with fire extinguishers, which shall comply with the requirements of SANS 10400 Building Regulations South Africa and other applicable requirements to keep people and property safe in the event of fire. The Contractor shall comply with General Safety Regulation 29.

1.5.8 Sanitation and Cleaning

The provisions regarding the Contractor's provision of sanitation and cleaning services shall apply to the Engineer's areas.

The Contractor shall further ensure that ablution and sanitation facilities are continuously supplied with soap, clean towels, toilet paper, etc.

The Contractor shall ensure that the wash bay facilities are supplied with detergents, clean wash cloths, towels and a high pressure washer.

The Contractor shall remove twice weekly all refuse including disposal thereof.

1.5.9 Electrical Power

Mains supply shall be through a 3-phase 4 wire 380/220 V 50 Hz LV cable distribution system with miniature substations, all in accordance with the general standards and specific requirements of Eskom.

The Contractor shall continuously provide, free of charge, such power to each building erected for the Engineer, by the date the buildings are to be used.

Suitable standby generating capacity shall be continuously available for immediate and automatic connection and supply in case of breakdown of the normal supply.

1.5.10 Water Supply

The Contractor shall provide and maintain, free of charge and by the date the offices are to be occupied, a continuous supply of water, sufficient to serve each of the Engineer's areas at a minimum pressure of 100 kPa under all operating conditions.

1.5.11 Sewerage and Sewage Treatment

The Contractor shall provide and maintain, free of charge and by the date the offices are to be occupied, the collection, treatment and safe disposal of sewage from the Engineer’s offices.

1.5.12 Construction Establishment Access Roads

The Contractor's obligations regarding the provision of construction establishment access roads to the Contractor's facilities shall apply for the Engineer's facilities.

1.5.13 Communications

Voice communications for the Engineer within the Site shall be by means of two-way radios procured by the Contractor from an established service provider in the area. The service provider shall have a long and acceptable history with regards to voice networks in the general area of the Site and shall also have a sufficiently large network and installation base in that area. The Contractor shall ensure that the service provider provides full coverage along the pipeline route as well as between all other areas of the Site by undertaking communication checks along the pipeline route and at each establishment area.

The two-way radios supplied by the Contractor to the Engineer shall conform to the following minimum functionality:

Radio Facilities:	**Call Facilities:**	
32 available channels	Individual Call	Emergency Call
QT/DQT encode and decode	Conference Call	Status Message Call
DTMF encode	Broadcast Call	Short Data Message
Time-Out timer	Inter-fleet Call	Call Diversion
Name Tag	PABX Call	Don’t disturb facility
Busy Channel Lockout	PSTN Call	Queue Incoming Call
TX Power Select		

The RF power output shall be 5 Watt maximum and 1 Watt minimum. The Contractor shall provide, and install in the case of the offices and vehicles, the number of radios as specified in the Specifications or Employer’s requirements:

Each portable hand-held radio shall have one charger, one belt clip, one sling and one spare battery (total 2 batteries). The battery life of the radio batteries shall be 1 Amp hour minimum.

At least three channels shall be available for the Engineer's exclusive use and one channel for communications between the Engineer and the Contractor. The Contractor shall ensure that all necessary licenses are obtained from the relevant authorities and maintained to operate the system for the duration of the Contract.

The Contractor shall ensure that the radio service for the voice networks and the satellite networks for the data (e-mail, internet service) are the most feasible solutions for the Site.

The Contractor shall be responsible for obtaining and maintaining the necessary licences.

1.5.14 Engineer's Site Equipment

The Contractor shall supply and service survey, photographic, field testing and laboratory equipment for exclusive use by the Engineer as specified in the Specifications or Employer's Requirements. All such equipment must be made available to the Engineer when required by the Engineer.

1.6 FACILITIES PROVIDED BY THE CONTRACTOR FOR THE WORKS

1.6.1 General

The Contractor shall provide and maintain the facilities on the Site for the durations required by the Contract.

The Contractor shall keep the working and establishment areas, and in particular the material lay down areas, neat and tidy.

All Subcontractor establishments must be contained within the Contractor's fenced establishment areas. On completion of the Works, Site fencing shall be removed and the Contractor shall reinstate disturbed areas in accordance with Section 47 – Landscaping and Rehabilitation.

For each designated area of the Site and its surrounds the Contractor shall within 28 days prior to the establishment of any facility or the commencement of any work thereon, make detailed records, including photographs and video records, of the existing state of all areas, structures, dwellings, facilities and other features that will be affected by his activities.

Such records, photographs, video material, drawings or statements as appropriate, shall be dated and two (2) copies of each shall be submitted to the Engineer prior to the establishment of that facility or the commencement of work in that area. The Contractor shall also maintain a duplicate record on Site.

Within 14 days after the Commencement Date (or earlier if required in terms of the Contract Programme) the Contractor shall submit a Method Statement together with general drawings, proposals and a programme for the establishment of the facilities provided by the Contractor to the Engineer for review.

The facilities referred to above shall include, but not be limited to, all buildings, offices, lay down yards, vehicle wash areas, fuel storage areas, screening Equipment (if necessary), batching areas and any other infrastructure required.

The Contractor shall be responsible for keeping all areas of the Site including temporary facilities, buildings, services, etc., in a neat, clean, sanitary and orderly condition.

The Contractor shall dismantle and remove from the Site all facilities which are no longer required, as agreed by the Engineer, and shall rehabilitate all affected areas in accordance with Section 47 - Landscaping and Rehabilitation.

1.6.2 Construction Establishment Fencing

Each construction establishment area for the Contractor shall be surrounded by boundary fencing with gates, to be provided, erected and maintained by the Contractor to properly surveyed and cleared lines. Boundary fencing shall be as specified in Section 6 – Fencing and shown on drawings.

In addition, the Engineer’s facilities, the Contractor's and Subcontractor’s offices, workshops, stores, explosives magazines, fuel depots and other sensitive facilities shall be surrounded by security fencing as specified in Section 6 – Fencing and shown on drawings. Security fencing shall be erected prior to the installation of any facilities inside the fenced area.

1.6.3 Lighting of Construction Establishment Areas

Flood-lighting of the areas shall be provided to allow safe movement of persons in each area at night. Lighting and floodlighting shall be of the downward facing spill off type.

1.6.4 Access and Haul Roads

(a) Construction Establishment Access Roads

The Contractor shall provide access and feeder roads as well as parking areas within the construction establishment areas. Each building shall be suitably connected to the roads and/or parking areas by way of footpaths 1 m wide. The roads shall be at least 6 m wide and parking areas shall be off-road.

The access and other roads and parking areas around the buildings shall be treated to make them dust free, by using crushed stone, bituminous surfacing and paving blocks. Spraying with water shall not be used. Footpaths shall be similarly treated to provide convenient access to all buildings.

Sufficient storm water drainage shall be provided to minimise the formation of puddles, ponds and the like, and shall include the measures specified in Section 27 – Drainage and Erosion Protection.

All construction vehicles from the Contractor which includes trucks and machinery, shall travel between 15km/h to 30km/h.

(b) Access/Haul Roads

Except for construction roads in the pipeline servitude, the Contractor shall not construct any new roads outside the pipeline servitude other than those specified.

The Contractor shall upgrade, construct or extend and maintain as necessary, temporary access, haulage or construction roads required for all weather usage, including the provision of road furniture, storm water drains and culverts, for the due fulfilment of the Contract. Where such roads require the approval of Provincial or Local Authorities, the Contractor shall be responsible for timely arrangements, and liaison with the relevant Authorities through the Engineer as well as for any levies, costs, charges and compensations that may be required. The Contractor shall provide the Engineer with copies of all correspondence in this regard.

The Contractor shall undertake periodic maintenance such as watering, grading, re-gravelling, pothole repair, of existing public roads that are being trafficked by construction vehicles. Maintenance standards shall be as specified in Section 26 – Road Maintenance.

Protection against shoulder damage will be required where gravel haul roads join surfaced roads as specified in Section 26 – Road Maintenance.

Where access roads are to be fenced and gated such as non-public roads, the Contractor shall be responsible for the fencing , gates and appropriate signs, in advance of using these access roads.

The Contractor’s Personnel may not enter at any time any private properties without the written permission and the co-ordination of the landowner and Engineer.

All access roads constructed by the Contractor in terms of this Clause shall be rehabilitated in accordance with Section 47 - Landscaping and Rehabilitation.

The Contractor to take note of the speed limits specified above.

(c) Access of Landowners

In certain areas the Works may intersect the only means of access to and from parts of the properties of certain landowners. In such areas the Contractor shall ensure continuous and safe vehicular access to these landowners by either constructing bypass roads and/or providing the owners of these vehicles with any necessary Health and Safety training and equipment for their vehicles to be

able to safely use the temporary access roads via the construction areas. The Contractor shall provide induction training to these landowners.

1.6.5 Electrical power and distribution

The Contractor shall provide his own electrical power for the Works. Where there is no power connection point, the Contractor shall provide, operate and maintain power supply generators and the like as required for the construction of the Works. All installations shall comply with the Eskom or relevant Local Authority regulations and be carried out by suitably qualified electricians.

Whenever the Contractor is engaged in night work he shall provide and maintain in good condition, adequate high powered flood lighting for all relevant parts of the Works.

The Contractor shall provide at the establishment areas suitable standby generating capacity, which shall be continuously available for immediate and automatic connection and supply in case of breakdown of the normal supply.

1.6.6 Water supply

The Contractor shall make all arrangements necessary for the provision, storage, purification and distribution of water for the due fulfilment of the Contract including to the various offices, buildings, other Site facilities and working fronts.

1.6.7 Sewage Treatment and Disposal

The Contractor shall provide for the reticulation, and collection of all sewage on the Site.

The treatment facilities at the construction establishment areas shall be conservancy tanks. Other facilities such as pit latrines, septic tanks, French drain systems or soak away systems, treatment plants etc. will not be permitted. Facilities shall conform to the by-laws of the relevant Local Authority and the National Environmental Management: Waste Act (Act 59 of 2008) and the Water Act (Act 36 of 1998) and the EIA, EA and EMPr. The Contractor shall provide 1 (one) sanitary facility for each sex and for every 30 (thirty) workers as per Construction Regulation 30(1)(b).

Adequate numbers of toilets for both genders and commensurate with the workforce shall be provided.

Mobile chemical toilet facilities shall be allowed along the pipeline route.

All ablution facilities, close to the Site boundaries or within sight of residential areas shall be hidden behind walls, screens or other suitable cover.

The Contractor shall ensure that toilets are always kept in a hygienic, fresh and disinfected condition by regular attendance and supplied with toilet paper, soap and towels. All toilets shall be

secured to the ground to prevent them from toppling over. All temporary mobile or portable toilets shall be fitted with screens on all windows and ventilation openings to keep out flying insects. Chemical toilets must be inspected on a daily basis to ensure they are in good working condition and not overflowing. A competent sub-contractor shall be appointed to service the toilets on a regular basis.

All sewage screenings and sludge shall be removed regularly as needed and disposed of at a wastewater treatment facility by a licensed service provider. If conservancy tanks are provided, the Contractor shall arrange for the removal and disposal of the sewage at such regular intervals as to avoid surcharging of the tanks, but at least once per week.

1.6.8 Communications

The Contractor shall provide all communication facilities to and within the Site for the due fulfilment of the Contract.

The Contractor shall be responsible for all arrangements necessary with the designated ISP (Internet Service Provider), other authorities and service providers. The Contractor shall also be responsible for all levies, charges, etc. in this regard.

The Contractor shall be responsible for connecting his local telecommunications network and systems into the ISP point of supply. Such communications shall be connected or provided such that effective and efficient communication within the Site and externally is maintained at all times during the Contract.

The Contractor shall be responsible for the operation and maintenance of all communications systems including the radio equipment.

The Contractor shall be responsible for obtaining reliable internet and e-mail facilities.

The Contractor shall supply and maintain two-way radios for his use and for the use of the Engineer.

1.6.9 Residential Accommodation

The Contractor shall not be permitted to construct residential accommodation at any of his construction establishment areas or on Site. Areas for residential accommodation of the Contractor’s Personnel shall only be established within existing developed areas zoned for residential housing, to the standards and approval of the relevant Local Authority.

1.6.10 Laboratory

The Contractor shall construct, furnish, equip (including heating/air conditioners) and maintain for the duration of the Contract a fully equipped Site laboratory in the vicinity of the Engineer's Site office.

The laboratory shall be managed, staffed and operated by the Contractor, but shall be available for use by the Engineer on a shared basis.

The laboratory facilities provided shall be constructed, furnished and managed in such a manner as to allow accurate performance of the tests to be carried out within the framework of the Contractor's Quality Management system.

The Contractor shall undertake all necessary testing in the Site laboratory and, if appropriate, at a commercial facility off Site. Only laboratories that are accredited by SANAS as being ISO 17025 compliant will be acceptable. It is the Contractor’s responsibility that the Site laboratory be inspected and audited at 6 monthly intervals by an independent SANAS accredited laboratory.

The Contractor shall:

a) Construct the laboratory of sufficient size and floor plan to accommodate all of his own needs, as well as those of the Engineer;
b) Fully service and maintain the laboratories to the same standards as for the Engineer's Office with electricity, Site access roads, raw and potable water, heating, sewerage and radios;
c) Provide and maintain equipment and apparatus of the respective types and extent necessary to enable all testing to be properly and efficiently undertaken. The equipment and apparatus shall all be in good working condition;
d) Provide all consumables required for the day to day running of the laboratory and auxiliary facilities;
e) Have undertaken by independent, recognised standards laboratories, initial and regular calibrations of all equipment and apparatus to a programme as agreed with the Engineer;
f) Provide and maintain equipment, apparatus and facilities necessary to enable all testing to be properly and efficiently undertaken at each working front;
g) Provide all labour, assistance and qualified testing staff as required;
h) Arrange for independent duplicate testing to be undertaken by a recognised commercial laboratory (SANAS accredited as being ISO 17025 compliant or similar) at a frequency as agreed with the Engineer; and
i) Dispose of waste generated by the laboratory in accordance with relevant Environmental regulations.

Notwithstanding any testing carried out by the Engineer, the Contractor shall remain responsible for ensuring that the Works are constructed in conformity with the Contract. He shall therefore undertake the proper testing, monitoring, quality control and reporting of test results, etc. within the framework of the Contractor's Quality Management System.

1.6.11 Project Name Boards and Signs

The Contractor shall, within 28 days after the Commencement Date provide, erect and maintain project name boards. The required number is specified in the Specifications or Employer's Requirements. The general arrangement of the boards is shown on the drawings and they shall be erected at locations agreed with the Engineer.

The Contractor and Subcontractors shall each be restricted to two company name boards within the Site boundaries of each of the construction establishment areas.

Name boards and signs shall be fabricated from durable materials such as Chromadex G275 (or equivalent) galvanised steel plate that will not distort due to weather conditions and shall be mounted on poles adequately braced to prevent wind damage. The Contractor shall keep all name boards and signs in good repair, order and legibility.

The Contractor shall be responsible for obtaining any approvals needed for the installation of name and signs boards in any location.

The Contractor shall remove all name boards, signs, supports and foundations on completion of the Contract and rehabilitate the areas in accordance with Section 47 – Landscaping and Rehabilitation.

1.6.12 Weather Measurements

The Contractor shall establish a weather station at his main establishment area or as agreed by the Engineer.

The Contractor shall continually record the following on a daily basis and submit the records weekly to the Engineer:

a) Continuous temperature readings;
b) Maximum and minimum daily temperatures;
c) Precipitation including hail;
d) Relative humidity;
e) Average hourly wind speed and direction; and
f) Barometric pressure.

If specified in the Specifications or Employer's Requirements, the Contractor shall also establish weather stations at positions agreed with the Engineer and submit weekly records of the following to the Engineer:

a) Daily maximum and minimum temperatures;
b) Daily precipitation including hail; and
c) Average hourly wind speed and direction.

The Contractor shall provide and maintain (including initial and subsequent calibration at least once every six months) standard weather recording instruments and house them in accordance with the manufacturer's instructions.

1.6.13 Medical

Adequate first aid stations shall be provided by the Contractor at suitable and easily accessible locations. The Contractor shall have 1 (one) trained first aider for every 50 (fifty) employees on Site. The Contractor to comply with General Safety Regulation 3 - First aid, emergency equipment and procedures.

The Contractor shall make all arrangements necessary for emergency services to transfer/evacuate serious cases to suitable local medical facilities e.g. hospitals or clinics including if necessary access to evacuation by air.

The Contractor shall provide a helipad and associated requirements (e.g. a windsock) to the Civil Aviation Authority standards at a suitable location.

1.6.14 Sanitation and Cleaning

(a) General

The Contractor shall maintain the Site and all facilities for which he is responsible under the Contract to ensure that they are in a clean, neat and sanitary condition at all times and shall comply with the Health and Safety Plan and EIA, EA and EMPr.

(b) Refuse Collection and Disposal

The Contractor shall be responsible for all collection, removal and safe disposal of Site refuse.

Metal refuse bins to BS 792 or equivalent plastic refuse bins, all with lids, shall be provided by the Contractor for all buildings and refuse shall be collected and removed from all facilities on the Site at least twice per week as per Construction Regulation 27. Refuse from food preparation and eating areas shall be collected and removed daily. Refuse shall be transported to a registered refuse disposal site in covered containers or covered trucks.

(c) Pest and Vermin Control

The Contractor shall propose and execute a programme agreed with the Engineer to control noxious pests and vermin on the Site. Use of residual pesticides will not be permitted.

1.6.15 Access control and security

(a) Access Control

The Contractor shall control access to the Site. At all access points to the servitude the Contractor shall provide access control by means of a security guard and lockable gates as per Section 6 – Fencing to prevent unauthorized persons from entering the pipeline servitude at all times.

(b) Security

The Contractor shall institute a security system to cover all areas of the Works.

The Contractor shall be responsible for providing, operating and maintaining the security system including personnel, vehicles, equipment, access control buildings, guard shelters, barriers/booms, identification systems, administration, management and the like.

The Contractor shall submit to the Engineer for review a Method Statement containing a full description of the proposed security policies and systems. The system shall operate on a continuous 24 hour per day 7 days per week basis for the duration of the Contract. The system shall include full and effective security control of all accesses to each work front including appropriate identification procedures for all persons and vehicles entering and leaving the Site.

The Contractor shall co-operate with the South African Police Services (SAPS) and comply with the Engineer's requirements on all matters relating to security of the Works and persons entering the Site.

The Contractor shall prevent firearms being brought on to the Site. Applicable signs shall be erected at the entrances to the Site.

Security staff shall be supplied with radio communication equipment to enable reliable communication between themselves and the Contractor and Engineer on Site.

1.6.16 Fire Control

The Contractor shall take all reasonable precautions against the outbreak of fire. Smoking may only be permitted in designated areas. All other areas of the Site shall be smoke free zones.

No open fires will be permitted in any area under the control of the Contractor. Grass and other vegetation in the vicinity of all buildings shall be cut at regular intervals to reduce fire hazards. Adequate fire breaks shall be cut and maintained in all areas within the control of the Contractor.

The Contractor shall provide:

a) Adequate fire detectors, fire alarms, fire extinguishing and firefighting equipment appropriate to the location and type of fire envisaged. These items shall be regularly maintained and inspected. Each item shall have an up-to-date test certificate.
b) A nucleus of personnel trained in firefighting, and in the use of firefighting equipment, such as respirators. These personnel shall be under the supervision of a person experienced in firefighting on construction sites.

The Contractor shall also provide and maintain at each of the work fronts adequate fire fighting services. The firefighting services shall be maintained in a good and ready state and shall be available on a continuous basis for each front, together with a water filling point for the tanker. The Contractor shall institute a warning and call out system to ensure that the firefighting teams and equipment can concentrate on any fire effectively, and in the appropriate manner, in the shortest possible time. The Contractor shall comply with Construction Regulation 29 - Fire precautions on construction cites.

The Contractor shall, in consultation with the Safety Committee and the Engineer, publish operating requirements governing the call out and use of the service. Notices in English and in any other languages as may be relevant to the workforce shall be prominently displayed giving instructions as to how the service can be summoned. The warning and call-out system shall be incorporated in the Contractor's emergency evacuation procedures required in the Health and Safety Specification.

The effectiveness of the service shall be tested at least 3 times each year under the monitoring of the Engineer.

1.7 PROGRAMMING REQUIREMENTS

1.7.1 General

The Contractor shall supply to the Engineer two original versions of the planning and programme software, each licensed for network use by 3 persons. The provision of this software shall include for upgrades for each license whenever these are issued by the supplier. Whenever the Contractor submits a programme to the Engineer he shall supply the Engineer with an electronic copy of each programme, together with a hard-copy print out of the bar chart or tabular report in a format agreed to by the Engineer. All programmes shall be prepared and submitted using this planning software.

The Contractor shall have submitted a programme with his Tender for the construction activities in connection with the various Parts of the Works. Such programme shall have been designated the "Tendered Programme", and shall form the basis of the Initial and Contract Programmes pursuant to the Conditions of Contract, Sub-Clause 8.3.
The detailed time programme to be submitted in terms of Sub-Clause 8.3 of the Conditions of Contract as the Contract Programme shall be an update and expansion of the Tendered Contract

Programme. Any revisions and alterations to the Contract Programme shall be in accordance with Conditions of Contract Sub-Clause 8.3 and with this Clause.

Requirements of and supporting data/information required with the Contract Programme and any updates thereto shall include the following as a minimum:

a) The Contract Programme shall be fully integrated, i.e. the programme, quantities and amounts and resources integrated;

b) The Contract Programme shall include information on shutdown periods, vacation days and other non-working time periods. Allowance shall also be made for climatic conditions (including wet seasons) and any conditions arising from climatic conditions, which allowances shall include for all effects not provided for in Sub-Clauses 8.4 (c) and 19.1 (v) of the Conditions of Contract accumulated over the whole Time for Completion;

c) The Contract Programme shall clearly show the interrelationship of all activities in the programme and shall include logic-linked annotated bar charts (Gantt charts). In particular, the linkages and constraints between activities/rational stages and resources deployment shall be clearly identified by way of a precedence network diagram, and shall show as far as reasonably practicable:

i) Commencement Date of the Works;
ii) The activities in all work packages including those by Subcontractors and suppliers.;
iii) The earliest and latest start and finish dates for every activity in each work package. Activities shall include all scope activities and any activities or time durations expected in addition to scope activities;
iv) Access dates for each Section or Part of the Works;
v) Completion dates for each phase, Section and Part of the Works;
vi) Milestone and key dates;
vii) Non-working periods;
viii) Dates by which Contractor’s Documents and/or samples will be submitted to the Engineer and dates by which responses to such documents or samples will be required by the Contractor, allowing time for submittals, re-submittals and reviews;
ix) Procurement, fabrication, delivery, construction, installation, testing and Tests on Completion of Plant;
x) Dates by which work will be ready for monitoring of testing by the Engineer;
xi) Details and dates by when any access permissions and/or information will be required from the Engineer or the Employer;
xii) The work contained in Provisional Sums;
xiii) Dates for rehabilitation and establishment of vegetation;
xiv) Provisions for float, time risk allowances, quality control procedures, health and safety, environmental requirements (and any other requirements that may be set out in the Contract);

xv) Scheduled servicing and/or maintenance inspections and works during the Defects Notification Period; and

xvi) Completion of the Works showing Ready for Pre-commissioning (RFPC), Ready for Commissioning (RFC), Ready for Trial Operation (RFTO) and Ready for Operation (RFO).

d) In relation to each activity, the following minimum information shall also be presented:

i) Unique identification number (ID);

ii) Description;

iii) Duration in working days;

iv) Key quantities and related overall production rates (i.e. the quantity and production required to accord with the duration of the activity);

v) Resources allocations/loading (including Contractor's Equipment, Temporary Works, supervision and labour) for the execution of the activity within its programmed duration;

vi) Calendar ID/designation;

vii) Early start date, early finish date and duration;

viii) Total and free float;

ix) Highlighting of the critical path through the programme, being that path (or chain of activities) that must be completed on time for the Works, Sections or Parts of the Works to be completed within the Time for Completion; and

x) Any periods of inactivity.

e) In support of the Contract Programme, and any revision required thereto in terms of the Conditions of Contract Sub-Clause 8.3, the following shall be submitted or revised, as the case may be:

i) Equipment and manpower resource schedules, and the spread and allocations of resources, including details of the Contractor's resource requirements in terms of manpower, gang sizes, tradesmen, work production rates, items of Plant or equipment and materials and quantities of work allowed for in sufficient detail to explain the Contractor's durations for each group of activities/work package consistent with the similar information linked with each activity;

ii) Activities or groups of activities/work packages that may be expedited by use of overtime, additional shifts or any other means shall be identified and explained;

iii) Identifying the days of working per week, hours and shifts per working day, non-working periods and holidays;

iv) Each referenced activity shall be clearly linked to the Method Statements;

v) A schedule of all submittals and material procurement activities, including time for submittals, re-submittals and reviews and time for fabrication and delivery of manufactured products. The interdependence of procurement and construction activities shall be included in the schedule;

vi) For all activities with float, a schedule of latest start and finish dates for the Engineer's reviews/responses where applicable to Contractor's Documents and/or samples; and

vii) A schedule stating the monetary value of each activity for cash flow purposes. The sum of the monetary values shall total the Contract Price. The schedule shall also state the payment items applicable to the activity monetary values.

f) The format of all outputs and reports from the Contract Programme shall be as agreed by the Engineer.

During the execution of the Contract the Contractor shall comply with the following minimum requirements for Contract Programme maintenance and progress monitoring as a dynamic working tool in managing the Contract:

a) The Contract Programme shall be maintained using the latest version of the planning software;

b) Five working days before each monthly progress meeting the Contractor shall submit to the Engineer a programme update that reflects the actual progress against current programmes and the effect on future activities. The programme update shall be scheduled using the first day of the succeeding progress month as the "data date";

c) The Contractor shall also submit a narrative report with each monthly update including a description of current and anticipated programme-related problem areas, current and anticipated delaying factors and their impact, and an explanation of corrective actions taken or proposed. The report shall also include a schedule showing information required from the Engineer on a 9 month moving window;

d) All variances from the Contract Programme shall be promptly reported to the Engineer and the future impact of such variations shall be determined and analysed by the Contractor using network logic and necessary corrective measures established and submitted to the Engineer in both electronic and hard-copy formats for review and response as to compliance with the Contract;

e) The Contractor shall submit to the Engineer a time impact analysis inter alia when, after due and prompt consultation with the Engineer:

i) If so required by the Engineer for purposes of evaluating the effect on the Contract Programme of a proposed variation;

ii) A current or anticipated delay significantly affects, or would affect, key dates or the sequence of activities;

iii) A significant change in the scope of Works is anticipated that is likely to negatively affect the Time for Completion and/or adjustments;

iv) An acceleration in accordance with Conditions of Contract or other time reduction that affects, or would affect, key dates or the sequence of activities;

v) The Contractor proposes to change any sequence of activities affecting the critical path for the Works, Sections or Parts;

vi) The Contractor proposes to significantly change, in the opinion of the Engineer, the Contract Programme;

vii) The Contractor proposes to significantly change, in the opinion of the Engineer, work methods, Method Statements, equipment, materials or manpower; and
viii) The Contractor submits a claim for any extension of time in terms of Sub-Clause 8.4 of the Conditions of Contract.

The time impact analysis shall, inter alia, demonstrate as appropriate:

a) How the Contractor proposes to incorporate the change, delay, variation, requested extension of time, acceleration or other time reduction into the programme;
b) The impact of each change, delay or time reduction on achieving key dates;
c) The impact of each variation or requested extension of the Time for Completion on achieving key dates;
d) The impact of each acceleration or other time reductions on the Contract and Programme; and
e) The identification of any other mitigation measures to minimise overall the impacts and any costs associated therewith.

When both the Contractor and the Engineer agree on the impact on the Contract Programme, of the change, delay or acceleration or other time reductions, the Contractor shall incorporate the appropriate logic revisions into a revised Contract Programme. Each revision shall be uniquely identified by sequential numbering. When the Contractor and Engineer cannot agree on the impact of the change, delay, extension, acceleration or other time reductions before the next monthly programme update, the Contractor shall incorporate logic revisions that will have the least negative impact on the Time for Completion. The Contractor shall maintain a record of any disagreements with the Engineer and the programme implications thereof.

1.7.2 Progress Meetings

The Contractor will be required to attend regular site meetings with the Engineer where the progress of construction will be reviewed. Such meetings will normally be held monthly and may be attended by representatives of the Employer and other interested stakeholders.

The Contractor shall also attend weekly meetings with the Engineer and provide, prior to each meeting as required by the Engineer, two weekly planning schedules showing separately the various activities of the Contractor anticipated over the forthcoming two-week period as well as the estimated progress on agreed key items achieved over the preceding week relative to the programme applicable to that period.

1.8 CONSTRUCTION MATTERS AND RECORDS

1.8.1 Contractor's Methods and Materials

Acceptance of the Tender will not signify acceptance of the Contractor's Equipment, proposed methods of construction, Tendered Contract Programme, Temporary Works or materials, nor will it

in any way relieve the Contractor of any of his responsibilities under the Contract. Further it will not be accepted as a basis for claiming additional compensation where the proposed methods of construction or the proposed materials do not comply with the Contract, regardless of whether accepted by the Engineer or not.

The Contractor shall submit to the Engineer for review full details of the key construction and key management processes to be applied in the implementation of the Works defined under this Contract. The process detail shall include, but not necessarily be limited to, the methods, equipment, materials and controls proposed for each aspect of the work or installation. These shall be referred to as Method Statements. These Method Statements define how the relevant work processes are to be executed by the Contractor to meet the requirements of the Contract.

The Method Statements integrate all aspects of the work and as such shall detail at least the following in a format and structure to be agreed with the Engineer:

a) Scope;
b) Goal of the construction activity;
c) Relevant Sections of the Specification and/or the Employer's Requirements;
d) References to the Standard Specifications and/or the Employer's Requirements and drawings;
e) Management and supervision;
f) Resources, including involvement of Subcontractors;
g) Technical execution/working methods;
h) Discipline integration;
i) Materials;
j) Equipment;
k) Occupational health and safety management;
l) Environmental and social management;
m) Quality management, control and assurance;
n) Communications;
o) Dangers and hazards identified, and measures and procedures to be implemented to ensure safe working environment and equipment;
p) Affected existing infrastructure and services, and measures to be implemented;
q) Training requirements for Contractor's Personnel;
r) Construction management requirements;
s) Programme; and
t) Any other aspects required by the Engineer or Contractor.

The preliminary method statements included in the tender document shall be supplemented and elaborated to fully detailed Method Statements. An indicative list of Method Statements is included in Annexure 1/1 of this Section.

The Contractor shall develop the Method Statements and submit them to the Engineer for review in order of priority. In order to avoid an overload in the approval process, the Contractor shall allocate a priority to each of his Method Statements submitted in accordance with the following allocations:

a) Priority 1 - most urgent, for work planned to commence between 28 and 56 days after submission;
b) Priority 2 - for work to be commenced between 56 and 84 days after submission; and
c) Priority 3 - least urgent, for work planned to be commenced after 84 days after submission.

The Contractor shall plan the submission of his Method Statements in accordance with the following 28-day programme:

a) First submission – as soon as possible, but not later than 28 days before the programmed commencement of the work forming the subject of the Method Statement. Where the lead time to implement a Method Statement requires early review by the Engineer, the Contractor shall make his first submission accordingly early;
b) Comments by the Engineer (if any) – will be given within 14 days of receipt of the first submission for Priority 1 works;
c) Final submission for Priority 1 works - within 7 days of receipt of the Engineer's comments;
d) Provided all the Engineer's comments have been addressed, final comments by the Engineer will be given by the Engineer within 7 days; and
e) For Priority 2 and 3 works the following durations shall be substituted for the above periods as stated in the table below:

TABLE 1/1
PROGRAMMES FOR METHOD STATEMENTS

	PRIORITY 2	**PRIORITY 3**
First submission	56	84
Comments by the Engineer	28	56
Final submission	14	14
Final comments by the Engineer	14	14

Note: Figures are days before work is programmed to commence.

To facilitate review of the Method Statement the Contractor shall engage in discussions with the Engineer's staff during development of the Method Statement.

Work on Site may not commence until the following Management Method Statements (MMSs) have been reviewed by the Engineer:

TABLE 1/2
INITIAL METHOD STATEMENTS REQUIRED

MMS 1	Occupational Health and Safety
MMS 2	Environmental and Social Management
MMS 3	Quality Assurance
MMS 4	Employment and Recruitment
MMS 5	Preferential Procurement
MMS 7	Subcontractor, Supplier and Service Provider Management
MMS 9	Construction Planning and Scheduling
MMS 10	Construction Management and Supervision
MMS 13	Security
MMS 14	Communication
MMS 15	Equipment Management
MMS 16	Site Accommodation and Transport
MMS 17	Site Establishment
MMS 18	Public Relations and Social Management
MMS 19	Access Control
MMS 20	Enterprise Development
MMS 21	Skills Development
MMS 22 etc.	Other MMSs identified by the Engineer

Construction or manufacturing work on any aspect/component/part of the Works requiring a Construction Method Statement (CMS) shall not commence without such a CMS reviewed by the Engineer.

Modifications may be required to the Method Statements from time to time. In such an event:

- The Contractor may propose modifications for the Engineer's review; and
- The Engineer may give notice to the Contractor of modifications required to ensure the contents of the Method Statement comply and continue to comply with the Contract and the Contractor shall within 14 days of such notice submit a revised Method Statement to the Engineer for review.

Any approval, consent, acceptance, agreement, review, comments etc., by the Engineer shall not relieve the Contractor from any obligation or responsibility under the Contract.

1.8.2 Quality Management

1.8.2.1 System and Procedures

The Contractor shall be responsible in terms of the Contract for the quality and testing of materials, workmanship and production processes in fulfilment of the Contract. To this end the Contractor shall establish, document, implement and maintain a Quality Management System based on ISO 9001.

The Quality Management System documentation shall include as a minimum:

a) Documented statements of a quality policy and quality objectives;
b) A quality manual;
c) Documented procedures;
d) Documents needed to ensure the effective planning, operation and control of processes; and
e) Records.

As part of the documentation the Contractor shall ensure the effective planning, operation and control of processes, institute and operate a Project Quality Plan (specific to the Contract) and complying, as a minimum, with ISO 10005.

The Contractor's Project Quality Plan (MMS1) shall specify which processes, procedures and associated resources will be applied by whom and when, to meet the requirements of the Contract. The contents of the Project Quality Plan shall detail as a minimum the following in order to satisfy the Standard relevant to each operation required for the execution of the Works in accordance with the Contract:

a) Scope;
b) Project Quality Plan inputs;
c) Quality objectives;
d) Management responsibilities;
e) Control of documents and data;
f) Control of records;
g) Resources;
h) Requirements;
i) Customer communication;
j) Design and development;
k) Purchasing;
l) Product and service provision;
m) Identification and traceability;
n) Customer property;
o) Preservation of product;
p) Control of non-conforming product;
q) Monitoring and measurement;
r) Audits;
s) Testing and reporting of testing;
t) Review, approval and integration of Subcontractor Project Quality Plans; and
u) Control of Method Statements, including Subcontractor Method Statements.

1.8.2.2 Acceptance of Quality Management System and Project Quality Plan

The preliminary Quality Policy Manual and preliminary Project Quality Plan shall be supplemented and elaborated to fully detailed manuals and plans under the headings given above, making use wherever possible of diagrams, charts, organograms, etc., in preference to lengthy descriptions.

The Contractor shall require Subcontractors to submit, for his approval, Project Quality Plans, at minimum, based on the headings required by ISO 10005: and the Contractor's Project Quality Plan. The Contractor shall include these Project Quality Plans, clearly indicating his approval, in his Project Quality Plan (ISO 10005).

1.8.2.3 Materials and Goods

(a) Proprietary Brands

Where the Standard, Specification or Employers Requirement refers to materials of a particular brand name the Contractor may offer an equivalent for the Engineer's approval but the Engineer is under no obligation to accept the alternative and no claims will be entertained if the alternative is not accepted.

(b) Testing of Materials

All testing shall be carried out and interpreted in strict accordance with the methods specified in the relevant Standards (South African, British, American, etc.). Testing and design work required in terms of a Standard may only be carried out by independent testing laboratories that are SANAS Accredited (as being ISO 17025 compliant). The Contractor may propose other testing laboratories to the Engineer for consideration. Use of any laboratories will be subject to the Engineer's review.

(c) Quality of Materials and Samples

When required by the Engineer, the Contractor shall furnish all information on the materials to be used in the Works and shall provide to the Engineer such other particulars as required.

Before placing any order for materials to be incorporated into the Works, the Contractor shall submit to the Engineer for information, the names of the suppliers supplying the materials providing, such details as the origin, manufacturer's specification, quality, weight, strength, description and the like. When requested, the Contractor shall provide samples, information and manufacturer's test certificates of the materials to be incorporated into the Works. The samples ordered or specified shall be delivered to the Engineer on Site, allowing sufficient time for the Engineer to inspect and/or test the samples before the material is required in the Works.

(d) Maintenance Support

Plant and Materials shall be selected to ensure continuous maintenance support to the Employer, post commissioning. To this end, only Plant and Materials which has a demonstrated historical, current and future maintenance repair and support presence in the South Africa shall be incorporated into the Works. The South African based support, maintenance and repair facilities shall be fully equipped and staffed with qualified personnel for supplying replacement parts and making repairs to Plant and Materials supplied under this contract and shall carry a full range of normal maintenance spares.

1.8.2.4 Competence of Workmen

The competence of personnel required to undertake operations involving particular skills affecting the quality of the Works, such as joint welding, lining and coating application to joints and repairs, etc. shall be demonstrated to the Engineer by means of tests arranged by the Contractor. Should the competence of any member of the Contractor's workforce be in doubt, the Engineer may order re-testing of a member at any stage throughout the Contract. Suitable means of identification of different skills and training levels of members of the workforce by way of badges or similar shall be instituted for certain skills as required by the Engineer.

The Contractor shall allow for monthly training and re-training sessions for applicators, supervisors and inspectors on the application of the joint lining and coating repair material unless otherwise agreed by the Engineer.

1.8.2.5 Inspection and Testing

The Contractor shall carry out sufficient inspections and tests to ensure that all requirements of the Specifications and Employer’s Requirements are being met and the results of inspections and tests shall be submitted to the Engineer in accordance with the Contractor’s Project Quality Plan. The Engineer may carry out further inspections and tests as he deems necessary.

Whenever the regular period for carrying on work is to be changed, the Engineer shall be given notice in sufficient time (at least 28 days) to rearrange staffing for proper inspection. The Engineer shall be given notice of any other proposed changes to normal working times at the weekly progress meetings or as necessary to cope with emergencies.

As much testing as is practicable shall be carried out on Site, including trial, acceptance and routine testing to be implemented by the Contractor, and any other tests as instructed by the Engineer for any complementary investigations required from time to time during the course of the Contract.

1.8.2.6 Approved Inspection Authority

The Approved Inspection Authority (AIA) is an accredited inspection authority, in terms of the South African National Accreditation System (SANAS), responsible for quality monitoring of specialised aspects (e.g. welding and corrosion protection) in the factories, other places of manufacturing and

on Site, similar to the function of the Engineer's staff. The AIA will sign off on the QCP hold points in the factories.

Although an Approved Inspection Authority (AIA) is appointed to independently monitor the quality of specialised aspects, this shall not absolve the manufacturers and Contractor from the obligation to implement their own quality assurance program for production purposes. The Employer recognizes that the radiographic weld testing on site is a time-consuming process and that it is not practical for the AIA execute this activity without potentially delaying production. To mitigate this risk, the Contractor shall allow for the testing of 100% of the field joints using his own appointed accredited weld testing inspectorate that forms part of the weld production inspection team. The Contractor will share these test results with the Engineer and AIA and the Engineer will also have the right to instruct additional independent ad hoc radiographic testing as and when required. The radiographic testing shall be digitally recorded for record purposes.

The Engineer and AIA will have the right to:

a) Review the Contractors and manufacturers quality assurance programmes for the work;
b) Review shop drawings, purchase orders, catalogues, samples, mill test reports, welding procedures, etc., to verify dimensions, quantity, materials, finishes, fits, etc.; and
c) During the course of planning, material procurement, manufacture and testing, review the quality of materials and workmanship, and to prepare regular inspection reports and copy them to the Employer.

The AIA will visit factories, review the manufacturing processes and witness tests.

The AIA's personnel shall be qualified to monitor and independently inspect the manufacture, coating and installation of large diameter pipes, valves, specials, pumps, electrical works and other specialised aspects identified by the Engineer, as well as equipment deemed necessary for such inspections. The AIA shall communicate with the Engineer regarding all technical matters relevant to the Contract.

1.8.3 Contractor's Records and Reports

Records and returns shall be reported to the Engineer in a format agreed with the Engineer.

1.8.3.1 Weekly Reports

The Contractor shall keep accurate daily records detailing work carried out on the Works and shall submit it to the Engineer as a sequentially numbered weekly report prior to the weekly progress meeting or at such other times as the Engineer may require.

The records shall include the following information for each Part of the Works separately and for each Subcontractor separately (where applicable):

a) Extent of work done to date by category, location and activity identification number from the Contract Programme;
b) The time and duration of any significant delays or breakdowns of any of the Contractor's Equipment;
c) Listing of any deficiencies or non-conformances and corrective action(s) undertaken;
d) Any other events relevant to the progress of the Works with reference to the Contract Programme and its detailed activities and work packages;
e) A list of information/instructions given and received and any conflicts in drawings and the Specifications and/or Employers Requirements;
f) Information/instructions required from the Engineer;
g) A list of quality assurance documents, procedures and records that were added, amended and/or updated;
h) A list of OH&S information submitted in accordance with Section 2 requirements; and
i) Weather and climate records.

The weekly report shall also summarise:

a) The work performed;
b) The work performed as referenced on the Programme; and
c) Information/instructions required from the Engineer.

The Contractor shall also provide such further information as may be requested by the Engineer.

1.8.3.2 Monthly Progress Reports

The Contractor shall submit monthly progress reports in accordance with Sub-Clause 4.21 of the Conditions of Contract. The Contractor shall in addition to this requirement provide a list of all information submitted pertaining to Section 2 requirements.

1.8.3.3 Progress Photographs

The Contractor shall maintain a photographic record showing the progress of the Works at the various work fronts, borrow/spoil areas (if applicable), construction establishment areas or any other related areas at a rate of at least one photograph per week of work in progress and recording, inter alia, the following:

a) All areas where major structures are to be constructed, in their virgin state and after clearing and grubbing;
b) Progressive photographs of all excavations and the materials encountered;
c) Progressive photographs of the pipe laying operations, including the placement of selected materials and backfill;

d) Progressive photographs of all formwork, reinforcement and concrete works;
e) Progressive photographs of all borrow pits before, during and on completion of activities therein (if applicable);
f) Any structures, fence lines, public or private access roads encountered;
g) Progressive photographs of all underwater activities and structures as may be practical;
h) Record photographs of any ancillary structures;
i) Progressive photographs of all mechanical and electrical installation works;
j) Progressive photographs of all control and instrumentation installation works;
k) Photographs of all incidents;
l) Progressive photographs of the management of all incidents;
m) Progressive photographs of all landscaping and rehabilitation activities;
n) Any specific photographs requested by the Engineer; and
o) Photographs of all completed structures.

Where directed by the Engineer, certain progress photographs shall be taken from a fixed location each month.

Electronic copies on a 500 GB external hard drive [in jpeg format taken with an 8-mega pixel (minimum) digital camera at a minimum resolution of 3000 x 2000] shall be delivered to the Engineer each month. One additional 500 GB external hard drive shall be available for the Contractor to record photographs while the Engineer download photographs from the other external drive submitted each month. The Engineer and Contractor shall exchange external hard drives once per month. The photographs will become the property of the Employer.

Photographs on the external hard drive shall be named and filed according to the structure outlined in Annexure 1/2 of this Section.

1.8.4 Management Meetings

The Engineer may from time to time require the Contractor's Representative to attend management meetings in order to review progress and/or the arrangements for future work, or should the Engineer considers it necessary to facilitate the Works.

Such meetings shall include the following:
a) Site Progress Meetings;
b) Design or Technical Meetings;
c) Contractual Management Meetings – more specifically handling all commercial and contractual issues;
d) Measurement Meetings;
e) Commissioning Meetings;
f) Inter-contract liaison Meetings;
g) Environmental Management Meetings;
h) Social Management Meetings;

i) Project Safety Meetings; and
j) Sundry other meetings.

Meetings under items (a) to (c) above, will be held on the basis of one of each every second week. These meetings may be held consecutively at the same venue, be combined into a single meeting or in other combinations as directed by the Engineer.

The Contractor shall record the meetings, compile minutes for the Engineer's review and distribute it to all attendees and other relevant persons.

No request to attend a meeting and nothing in the minutes of such meetings shall constitute a notice or communication as required under Sub-Clause 20.1 of the Conditions of Contract (Contractor's Claims). Any such notice or communication shall be given strictly in accordance with Sub-Clause 20.1 of the Conditions of Contract and shall be issued separately.

1.8.5 Accommodation of Traffic

It is a requirement that the Works do not disturb the normal flow of traffic on public roads or compromise the safety of the general public. The use of public and private roads, traffic accommodation and the manner in which the work is to be carried out is to be addressed in the Contractor's Method Statements and Health and Safety Plan.

Where the Works or use of public and private roads may affect the safety or operation of pedestrians or traffic, the Contractor shall provide and maintain such traffic signs, barricades, warning lights and flagmen as are necessary. The Contractor shall be solely responsible for complying with the "South African Road Traffic Signs Manual as published by the Department of Transport, as well as any specification and/or requirements of the relevant statutory and local authority.

1.8.6 Servicing during Defects Notification Period

Without limiting in any way the liability of the Contractor for remedying defects, the Contractor shall make regular and at least quarterly visits to each installation during the Defects Notification Period to inspect the Works and service the Plant. During these visits he shall make all adjustments and do everything necessary to ensure the proper running of the Plant.

After each servicing visit to the Site the Contractor shall submit to the Engineer a report on:

a) The condition of the Works and the servicing work carried out;
b) Any adjustments which were made; and
c) The degree to which operators have become conversant with the equipment.

The last servicing visit shall be carried out during the last week of the Defects Notification Period. During this visit the Contractor shall carry out full checks on the Works to ensure that the alignment, clearances and any other settings are correct and shall carry out any adjustments necessary.

The Contractor shall give the Engineer one month notice of the planned dates of the Site visits and amend the dates if requested by the Engineer.

During the entire Defects Notification Period the Contractor shall maintain appropriate facilities and resources in close proximity to the Works in order that it can react to and correct a defect in the Works within the time periods instructed by the Engineer as specified in Sub-Clause 11.1 of the Conditions of Contract. The Contractor shall itself determine the appropriate spares and resource levels required to comply with the specified reaction and correction periods. Failure to comply with the specific periods shall entitle the Employer to the remedies set out in Sub-Clause 11.4 in the Conditions of Contract.

1.8.7 Interfaces with Existing Infrastructure

The detail of the points of supply are indicated on the drawings.

The Contractor shall identify existing services such as pipeline, power cables, telecommunication cables, etc. and ensure that such services are not damaged where the Works intersects with such services. The Contractor shall for this purpose ensure that markers and beacons associated with such services be maintained at all times with a view to avoid incidents of damage to these services.

1.9 DRAWINGS AND CORRESPONDENCE

1.9.1 Drawings and Co-ordination

The tender drawings issued with the Tender Documents are of a general nature only. Tender drawings are not to be used for construction or for ordering of materials.

Additional and modified drawings shall be issued by the designer for purpose of construction. Such drawings will be issued with due consideration of the programme of manufacture and construction after co-ordination with the Contractor. In particular, the Contractor shall indicate in the drawing Issue Schedule the lead times for critical drawings.

Where the Contractor's Equipment and Temporary Works or Plant may have an effect or impose forces on any part of the Permanent Works the Contractor shall, after co-ordination with the Engineer and having due regard for the dates given in the Drawing Issue Schedule, timely submit a Contractor’s Document giving all necessary details for incorporation into the detailed design and drawings of the Works.

The Contractor shall submit drawings in the following stages to the Engineer for review:

- Tender design drawings;
- Detailed design and workshop drawings, to be issued for manufacturing and construction;
- Amendments during construction; and

- As built drawings.

1.9.2 Correspondence to the Engineer

All correspondence from the Contractor to the Engineer shall address only one main contractual topic in each correspondence item. Correspondence shall be dated, sequentially numbered and distributed in accordance with a procedure agreed with the Engineer.

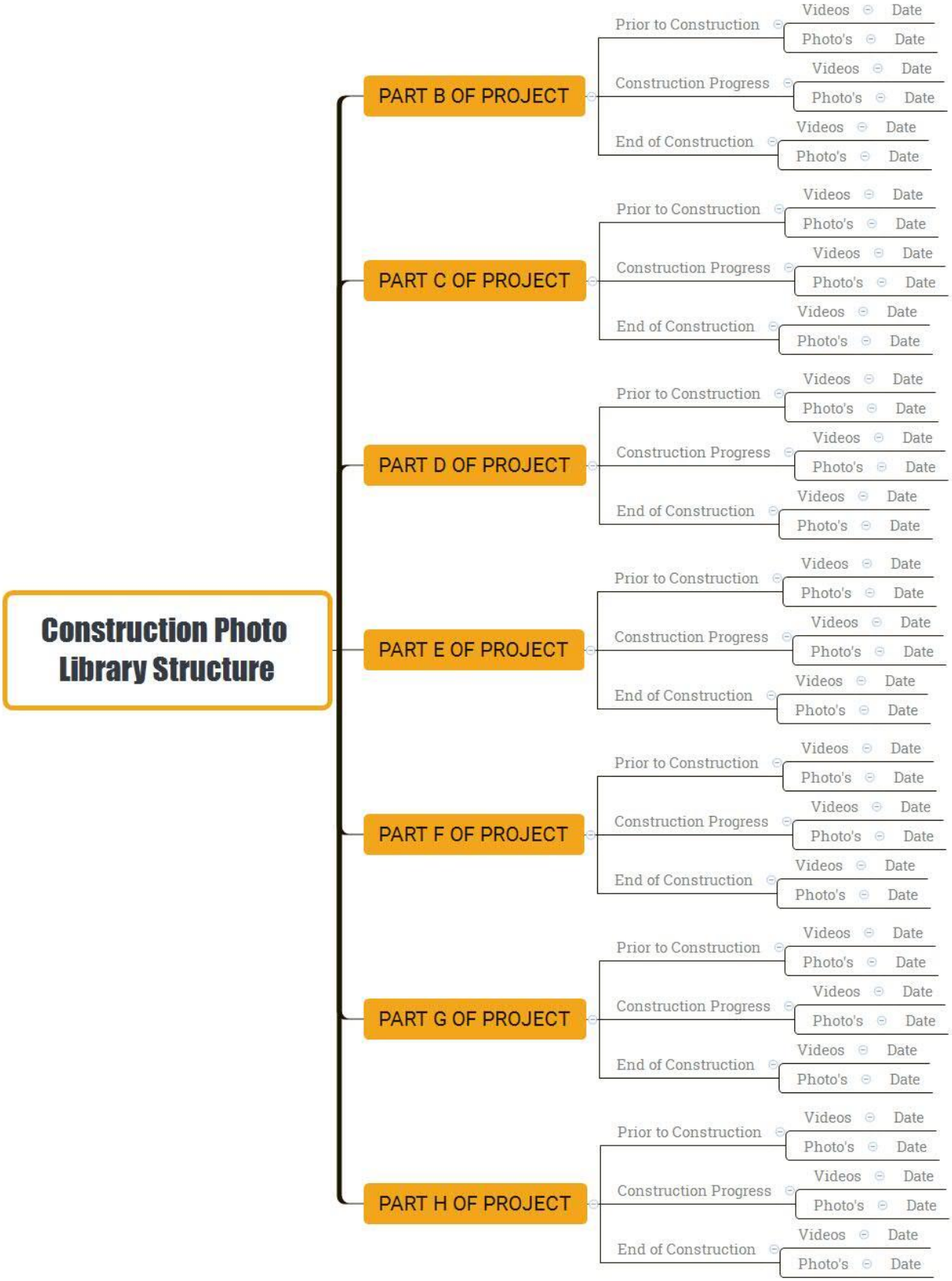
ANNEXURE 1/1
KEY METHOD STATEMENTS

MS Number	Key Method Statements (MS)	Engineer requires detailed MS post award of Contract
	Key Management Process MS	
MMS 1	Occupational Health and Safety	√
MMS 2	Environmental Management	√
MMS 3	Quality Assurance	√
MMS 4	Employment and Recruitment	√
MMS 5	Preferential Procurement	√
MMS 6	Procurement Management	√
MMS 7	Subcontractor, Supplier and Service Provider Management	√
MMS 8	Pipe Supply Management	√
MMS 9	Construction Planning and Scheduling	√
MMS 10	Construction Management and Supervision	√
MMS 11	Contractors Design	√
MMS 12	Commissioning	√
MMS 13	Security	√
MMS 14	Communication	√
MMS 15	Equipment Management	
MMS 16	Site Accommodation and Transport	√
MMS 17	Site Establishment	√
MMS 18	Public Relations	√
MMS 19	Access Control	√
MMS 20	Enterprise Development	√
MMS 21	Skills Development	√
MMS 22	Maintain Site Services	√
MMS 23	Management of blasting activity notifications	√
MMS 24	Others as Instructed by the Engineer	√
	Key Construction Process MS	
CMS 1	Surveying and Setting Out	√
CMS 2	Construction Fencing	√
CMS 3	Clearing Site	√
CMS 4	Dealing with Water	√
CMS 5	Construction Lighting	√
CMS 6	Fire Control	√
CMS 7	Haul Road Construction	√
CMS 8	Dust Suppression	√
CMS 9	Road Signage	√
CMS 10	Road Maintenance	√
CMS 11	Mobile Cranage	√
CMS 12	Stripping Top Soil	√

MS Number	Key Method Statements (MS)	Engineer requires detailed MS post award of Contract
CMS 13	Managing Fertile Soil	√
CMS 14	Pipe Trench Excavation	√
CMS 15	River Diversion and Impoundment	√
CMS 16	Drilling and Grouting	√
CMS 17	Drilling and Blasting	√
CMS 18	Bulk Surface Excavation	√
CMS 19	Rock Support	√
CMS 20	Pipe Manufacturing and Factory Testing	√
CMS 21	Pipe Handling, Transportation and Storage	√
CMS 22	Pipe Laying and Testing	√
CMS 23	Details of Welding and Weld Testing	√
CMS 24	Radiographic Testing	√
CMS 25	Joint Repairs (Lining)	√
CMS 26	Joint Repairs (Coating)	√
CMS 27	Monitoring of Pipe Coating Integrity	√
CMS 28	Mass Haul Management	√
CMS 29	Spoil and Borrow Pit Management (if applicable)	√
CMS 30	Bedding	√
CMS 31	Backfilling	√
CMS 32	Cathodic Protection and AC Mitigation	√
CMS 33	Air Valve Chamber Construction	√
CMS 34	Scour Valve Chamber Construction	√
CMS 35	Isolating Valve, Pigging Chamber Construction	√
CMS 36	Embankment Construction	√
CMS 37	Concrete Batching	√
CMS 38	Polluted Water Treatment	√
CMS 39	Reinforcement Steel Fixing	√
CMS 40	Concrete Shuttering	√
CMS 41	Scaffolding	√
CMS 42	Concrete Pouring	√
CMS 43	Concrete Pumping	√
CMS 44	Concrete Floor Construction	√
CMS 45	Concrete Curing	√
CMS 46	Concrete Finishing	√
CMS 47	Concrete Repairs	√
CMS 48	Built in Components	√
CMS 49	Erection of Steel Structures	√
CMS 50	Install Roofing Sheets	√
CMS 51	Brickwork Construction	√

MS Number	Key Method Statements (MS)	Engineer requires detailed MS post award of Contract
CMS 52	Paving Construction	√
CMS 53	Gravel Road Construction	√
CMS 54	Gabion Erosion Protection Construction	√
CMS 55	Pump Manufacturing and Testing	√
CMS 56	Valve Manufacturing and Testing	√
CMS 57	Pipe Special Manufacturing and Testing	√
CMS 58	Overhead Crane Manufacturing and Testing	√
CMS 59	Installation of Mechanical Plant	√
CMS 60	Pump Motor Manufacturing and Testing	√
CMS 61	Soft Starter Manufacturing and Testing	√
CMS 62	Transformer Manufacturing and Testing	√
CMS 63	Switch Gear Manufacturing and Testing	√
CMS 64	Installation of Electric Cables	√
CMS 65	Installation of Electrical Plant	√
CMS 66	Control Systems for Manufacturing and Testing	√
CMS 67	Installation of Fibre Optic Cable	√
CMS 68	Installation of Control Systems System	√
CMS 69	Installation of Security System	√
CMS 70	Construction of Security Fencing	√
CMS 71	Construction of Security Fencing (Electric)	√
CMS 72	Landscaping	√
CMS 73	Reinstatement of vegetation (Rehabilitation)	√
CMS 74	Installation of Microwave Towers Masts	√
CMS 75	OTDR Testing of Fibre Optic Cables	√
CMS 76	Network Design Philosophy (Primary and Secondary Networks)	√
CMS 77	Others as instructed by the Engineer	√

ANNEXURE 1/2
TYPICAL PHOTOGRAPHIC LIBRARY STRUCTURE


Construction Photo Library Structure
PART B OF PROJECT
PART C OF PROJECT
PART D OF PROJECT
PART E OF PROJECT
PART F OF PROJECT
PART G OF PROJECT
PART H OF PROJECT
Prior to Construction
Construction Progress
End of Construction
Videos
Photo's
Date

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 2

OCCUPATIONAL HEALTH AND SAFETY

TCTA MODULAR STANDARDS
SECTION 2
OCCUPATIONAL HEALTH AND SAFETY

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SECTION 2
OCCUPATIONAL HEALTH AND SAFETY

2.1 GENERAL

2.1.1 General Obligations

Apart from this Section the Contractor shall comply with the Occupational Health and Safety Act (Act No 85 of 1993) (the "OH&S Act") and its regulations, the Compensation for Occupational Injuries and Diseases Act (COIDA), (Act 130 of 1993) and, for work within borrow pits the Mine Health and Safety Act, (Act 29 of 1996).

The Contractor shall take full responsibility for the prevention of unhealthy and unsafe working conditions and practices and for the promotion of a healthy Site and safe working practices on the Site in so far as such conditions and practices affect his employees and any other persons on the Site.

Nothing specified in the Contract shall relieve the Contractor of his obligations and responsibilities with regard to Occupational Health and Safety (OH&S), and he shall, in terms of Sections 8 and 9 of the OH&S Act, prevent such conditions as may be prejudicial to the safety and welfare of his employees or of other persons on the Site from occurring on the Site.

Where persistent non-compliance with the OH&S Act, the requirements of this Section or the Contractor's OH&S Plan comes to the attention of the Engineer, he may, in terms of Construction Regulation 4(1)(e), stop the work or part of the work until the Contractor rectifies the non-compliance.

The Contractor shall institute systems that are safe and provide and maintain construction equipment and tools that are safe and in a good state of repair.

The OH&S Plan to be drawn up by the Principal Contractor shall be based on the requirements of the OH&S Baseline Risk Assessment and safety requirements. The Contractor may not commence construction work (including Site establishment) until this OH&S Plan has been approved by the Client/ Safety Agent.

This OH&S Modular Standard, the Contractor's OH&S Plan as well as the Construction Regulations, 2014 (the Construction Regulations) shall be available on Site for inspection by all workers, employees, inspectors and any other persons entering the Site of the Works. Although reference is made in the TCTA Modular Standards to specific Acts and Construction Regulations, it shall be the responsibility of the Contractor to comply with all relevant Acts and Regulations."

2.1.2 Definitions

For the purposes of this Section the following shall apply:

"Agent" means a competent person who acts as a representative for a Client and shall be either the Safety Agent in terms of the OH&S Act and Construction Regulations or the Engineer in terms of the FIDIC Conditions of Contract;

"angle of repose" means the steepest angle of a surface at which a mass of loose or fragmented material will remain stationary in a pile on the surface, rather than sliding or crumbling away;

"bulk mixing plant" means machinery, appliances or other similar devices that are assembled in such a manner so as to be able to mix materials in bulk for the purposes of using the mixed product for construction work;

"Client" in terms of the OH&S Act and Construction Regulations means any person for whom construction work is being performed and it has the same meaning as Employer in terms of the FIDIC Conditions of Contract.

"competent person" means a person who has, in respect of the work or task to be performed, the required knowledge, training and experience and, where applicable, qualifications, specific to that work or task: Provided that where appropriate qualifications and training are registered in terms of the provisions of the National Qualification Framework Act, 2000 (Act No.67 of 2000), those qualifications and that training must be regarded as the required qualifications and training; and is familiar with the Act and with the applicable regulations made under the Act;

"construction manager" means a competent person responsible for the management of the physical construction processes and the coordination, administration, and management of resources on a construction site;

"construction site" means a workplace where construction work is being performed;

"construction supervisor" means a competent person responsible for supervising construction activities on a construction site;

"construction vehicle" means a vehicle used as a means of conveyance for transporting persons or material, or persons and material, on and off the construction site for the purposes of performing construction work;

"construction work" means any work in connection with -

- the construction, erection, alteration, renovation, repair, demolition or dismantling of or addition to a building or any similar structure; or
- the construction, erection, maintenance, demolition or dismantling of any bridge, dam, canal,

road, railway, runway, sewer or water reticulation system; or the moving of earth, clearing of land, the making of excavation, piling, or any similar civil engineering structure or type of work;

"construction work permit" means a document issued in terms of regulation 3;

"contractor" in terms of the OH&S Act and Construction Regulations means an employer who performs construction work and includes organisations and/or self-employed persons that contracts with a Client, Principal Contractor, or a contractor to carry out construction work. It also includes Subcontractor in terms of the FIDIC Conditions of Contract. The terms “contractor” and “Principal Contractor” have the same meaning as that in the Construction Regulations and are used interchangeably in this document, i.e. references to “contractor” refer to Principal Contractor and/or contractor as the regulations pertain to their functions. ;

"demolition work" means a method to dismantle, wreck, break, pull down or knock down of a structure or part thereof by way of manual labour, machinery, or the use of explosives;

"design" in relation to any structure, includes drawings, calculations, design details and specifications;

"designer" means a competent person who-

- prepares a design;
- checks and approves a design;
- arranges for a person at work under his or her control to prepare a design, including an employee of that person where he or she is the employer; or
- designs temporary work, including its components;
- an architect or engineer contributing to, or having overall responsibility for a design;
- a building services engineer designing details for fixed plant;
- a surveyor specifying articles or drawing up specifications;
- a contractor carrying out design work as part of a design and building project; or
- an interior designer, shop-fitter, or landscape architect;

"ergonomics" means the scientific discipline concerned with the fundamental understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimise human well-being and overall system performance;

"excavation work" means the making of any man-made cavity, trench, pit or depression formed by cutting, digging or scooping;

"explosive actuated fastening device" means a tool that is activated by an explosive charge and that is used for driving bolts, nails, and similar objects for the purpose of providing fixing;

"fall arrest equipment" means equipment used to arrest a person in a fall, including personal equipment, a body harness, lanyards, deceleration devices, lifelines, or similar equipment;

“falsework” means a combined system of formwork and support work;

“formwork” means temporary or permanent shutters used to form wet concrete into elements of a structure, and includes both horizontally and vertically placed shutters;

"fall prevention equipment" means equipment used to prevent persons from falling from a fall risk position, including personal equipment, a body harness, lanyards, lifelines or physical equipment such as guard-rails, screens, barricades, anchorages or similar equipment;

"fall protection plan" means a documented plan, which includes and provides for -

- all risks relating to working from a fall risk position, considering the nature of work undertaken;
- the procedures and methods to be applied in order to eliminate the risk of falling; and
- a rescue plan and procedures;

"fall risk" means any potential exposure to falling either from, off or into;

"health and safety file" means a file, or other record containing the information in writing required by these Regulations;

"health and safety plan" means a site, activity or project specific documented plan in accordance with the Client's health and safety specification;

"health and safety specification" means a site, activity or project specific document prepared by the Client pertaining to all health and safety requirements related to construction work;

"material hoist" means a hoist used to lower or raise material and equipment, excluding passengers;

"medical certificate of fitness" means a certificate contemplated in Construction Regulation 7(8);

"mobile plant" means any machinery, appliance or other similar device that is able to move independently, and is used for the purpose of performing construction work on a construction site;

"National Building Regulations" means the National Building Regulations made under the National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977), and promulgated by Government Notice No. R. 2378 of 30 July 1990, as amended by Government Notices No's R. 432 of 8 March 1991, R. 919 of 30 July 1999 and R. 547 of 30 May 2008;

"Principal Contractor" means an employer appointed by the Client to perform construction work and it has the same meaning as Contractor in terms of the FIDIC Conditions of Contract. The terms “contractor” and “Principal Contractor” have the same meaning as that in the Construction Regulations and are used interchangeably in this document, i.e. references to “contractor” refer to Principal Contractor and/or contractor as the regulations pertain to their functions.

"Professional Engineer " means a person holding registration as a Professional Engineer in terms of the Engineering Profession Act, 2000 (Act No. 46 of 2000);

"provincial director" means the provincial director as defined in regulation 1 of the General Administrative Regulations, 2003;

"scaffold" means a temporary elevated platform and supporting structure used for providing access to and supporting workmen or materials or both;

"shoring" means a system used to support the sides of an excavation and which is intended to prevent the cave-in or the collapse of the sides of an excavation;

"structure" means-

- any building, steel or reinforced concrete structure (not being a building), railway line or siding, bridge, waterworks, reservoir, pipe or pipeline, cable, sewer, sewage works, fixed vessels, road, drainage works, earthworks, dam, wall, mast, tower, tower crane, bulk mixing plant, pylon, surface and underground tanks, earth retaining structure, or any structure designed to preserve or alter any natural feature, and any other similar structure;
- any falsework, scaffold or other structure designed or used to provide support or means of access during construction work; or
- any fixed plant in respect of construction work which includes installation, commissioning, decommissioning, or dismantling and where any construction work involves a risk of a person falling;

“support work” means the temporary structure erected to support the formwork before the casting of a concrete element of a structure.

"suspended platform" means a working platform suspended from supports by means of one or more separate ropes from each support;

"temporary works" means any falsework, formwork, support work, scaffold, shoring or other temporary structure designed to provide support or means of access during construction work;

"the Act" means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993);

"tunnelling" means the construction of any tunnel beneath the natural surface of the earth for a

purpose other than the searching for or winning of a mineral.

2.1.3 Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
COID	Compensation for Occupational Injuries and Diseases
COVID	Corona Virus Disease
CV&MP	Construction Vehicle and Mobile Plant
DIFR	Disabling Injury Frequency Rate
HBA	Hazardous Biological Agents
HIV	Human Immunodeficiency Virus
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
WBGT	Wet- Bulb Globe Temperature

The Construction Health & Safety Agent is referred to as the Safety Agent.

The Construction Health & Safety Officer shall be referred to as the Safety Officer.

2.1.4 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard, including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

2.1.5 Notification of Commencement of Construction Work

In compliance with the requirements of Construction Regulation 3, the Client will apply for a construction work permit once the Principal Contractor is appointed, in time to provide a copy to the Contractor before the Commencement Date.

The Contractor shall keep a copy of the construction work permit contemplated in sub-regulation (1) in the Occupational Health and Safety File for inspection by an inspector, the Client, the Client's authorised agent, or an employee. A copy of the construction work permit will also be displayed at the entrance to the construction Site.

After award of the Contract, but before commencement of Site establishment and construction work, the Contractor shall, in terms of Construction Regulation 4, notify the appropriate Provincial Directors of the Department of Labour in writing of the intended construction work.

The notification must be done in the form of the pro forma included under Annexure 2 of the Construction Regulations included in this Section.

One copy of the notification form must be submitted to the Client and one copy kept on Site in the Health and Safety File, available for inspection by inspectors, Client, Client's Agents, employees and other persons on Site.

2.1.6 Occupational Health and Safety Specification

In terms of the Construction Regulation 5(1)(a), the Client has compiled this Section of the Modular Standards and it shall serve as the OH&S Specification for this project.

2.2 OH&S PLAN

The Contractor shall prepare the OH&S Plan in terms of Regulation 7(1) and this Section.

In order for the Client to approve the OH&S Plan, the Contractor shall demonstrate to the Client that he has a suitable and sufficiently documented OH&S Plan as well as the necessary competencies, experience and resources to perform the construction work safely. No Site establishment or construction work shall commence before receipt by the Contractor of approval of the OH&S Plan.

The OH&S Plan shall be submitted to the Client within 28 days after the Date of the Letter of Acceptance but no later than 28 days before the planned Commencement Date.

Upon the Client's approval, the Contractor shall immediately implement the OH&S Plan and any amendments and keep it in operation for the full duration of the Contract.

The preliminary OH&S Plan included in Schedule H in Volume 1 shall be supplemented and elaborated to a fully detailed Plan.

The Contractor has to provide and demonstrate to the Client a suitable, sufficiently documented and coherent site specific health and safety plan, based on the Client's documented health and safety specifications contemplated in regulation 5(1)(b), which plan must be applied from the date of commencement of and for the duration of the construction work and which must be reviewed and updated by the Principal Contractor as work progresses. The plan must be accompanied by the following:

- Management structure;
- Quality plan;

- Human resources plan;
- Registered workplace skills plan;
- "Letter of good standing" from the Compensation Commissioner or licensed compensation insurer;
- Proof of induction and other training of employees; and
- Copy of minutes as an example of other project's occupational health and safety committee meetings and copies of incident investigation reports.

The OH&S Plan shall include the following:

a) An OH&S Management Programme, which shall include at least a detailed overview of the following:
   - Management of health and safety risks;
   - Structure and schedule of health and safety appointments;
   - Programme of induction and other training;
   - Programme of weekly toolbox talks and subjects, OH&S awareness programmes and promotion of health and safety;
   - Overview of the management of health and safety representatives;
   - Programme of health and safety committee meetings to be held by the Contractor; and
   - Programme of health and safety audits and inspections by the Contractor.

b) A description of communication and management of the work, including at the minimum the following:
   - Management structure and responsibilities;
   - Health and safety objectives for the project and arrangements for monitoring and review of health and safety performance; and
   - Arrangements for:
     - Regular liaison between parties on Site;
     - Consultation with the workforce;
     - The exchange of design information between the Principal Contractor, Client's Agents, supervisors and contractors on Site;
     - Handling design changes during the project;
     - Selection and control of contractors;
     - The exchange of health and safety information between all contractors;
     - Security;
     - Site induction and on-Site training;
     - Facilities and first-aid;
     - The reporting and investigation of accidents and incidents;
     - The production, approval and review of Risk Assessments and Method Statements;
     - Site health and safety rules;
     - Emergency contingency planning and procedures (including fire protection);
     - Reporting to the Client i.e., results of health and safety audits and inspections,

incident and incident investigations and committee meetings;
- Reporting of incidents to the Department of Labour, the Compensation insurer, Commissioner and the Client;
- Liaison with the environmental management and control discipline; and
- Two-way radio systems to be used where cell phone coverage is poor.

c) Arrangements for controlling Site risks

The following are examples required for formal arrangements for controlling Site risks:

i) Safety risks
- Services, including permanent and temporary electrical installations;
- Preventing employees from falling into excavations, from trucks etc.;
- Work with, on or near fragile materials;
- Lifting operations;
- The maintenance of Plant and equipment;
- Ensuring excavation safety and dealing with poor/unstable ground conditions;
- Traffic routes and segregation of vehicles and pedestrians;
- Storage and handling of hazardous materials and substances;
- Dealing with existing unstable structures/land;
- Accommodating adjacent land use;
- Emergency contingency planning and preparedness;
- Work in proximity to water;
- Moving of machinery on farmers land;
- Other safety risks as and when identified.

ii) Health risks
- Storage and handling of hazardous chemical, substances and other hazardous materials;
- Dealing with contaminated land or material;
- Manual handling;
- Reducing noise and vibration;
- Provision of adequate lighting;
- Ventilation considerations;
- Extreme heat and cold temperature considerations;
- Dealing with HIV/Aids and other illnesses;
- Provision of and maintaining ablution and eating facilities;
- Dealing with dust; and
- Other significant health risks as and when identified.

2.3 OH&S FILE

2.3.1 General

The OH&S file, opened in terms of Construction Regulation 7(7), shall be kept on Site at all times.

This shall be a file or other permanent record containing information on aspects of the Contract that will be necessary to ensure the OH&S of any person who may be affected by the construction work.

The Principal Contractor shall appoint a suitably qualified person to prepare the file and to keep it up to date for the duration of the Contract. The file shall include the following information, as a minimum:

No	Item	Notes
1	**Project directory**	Details of the Client, Project Manager/Principal Agent, Safety Agent, Engineer, etc. (Name, address, contact details).
2	**Contractors directory**	Details, trade, and FEM details of contractors.
3	**Other parties directory**	Contact details for any services applicable (electricity, water, etc.) as well as Department of Labour and Emergency Services.
4	**Project safety statement**	To be included in the Safety Plan.
5	**Health and Safety standards for the project (OHS Act, construction regulations, basic conditions of employment, etc.)**	To be included in the Safety Plan.
6	**Project particulars**	Scope of works must be included in the Safety Plan.
7	**Existing environment – structures and surroundings, services (electrical, water, sewerage, etc.), traffic arrangements, parking, access to site, storage of Plant and Materials**	To be included in the Safety Plan. The items must be Site specific, and include the location of services and services that will be affected.
8	**Management structure for safety on the project**	A structured organogram with names of the responsible people must be included.
9	**Appointed supervisory persons**	The required appointments must be identified. A list of the appointed persons must be included in the Safety Plan.
10	**Security Procedures**	Indicate if a security company will be appointed and include the contact information in the Safety Plan.
11	**Registers list and inspection frequency**	A list of the Inspection Registers that will be on file must be included in the Safety Plan.
12	**Design co-ordination**	Indicate procedure for implementation of design changes by designer on the project, and the procedures for liaison and implementation of temporary works design on the project.
13	**Contractor co-ordination**	Mention must be made of how contractors will be co-ordinated on Site to ensure that they work together

No	Item	Notes
		and not adversely affected health and safety.
14	**Housekeeping, stacking and storage**	Housekeeping policies and procedures must be included in the Safety Plan.
15	**Waste disposal arrangements**	Waste disposal arrangements procedures must be included in the Safety Plan.
16	**Noise and dust control**	Indicate if any noisy operations (more than 85 decibels) will be carried out and what measures will be used to reduce noise exposure to workforce.
17	**Training requirements**	Training requirements must be identified and recorded.
18	**Plant and Equipment**	A list of Plant and Equipment to be used on site must be included in the Safety Plan.
19	**Safety monitoring arrangements**	The name, contact details and SACPCMP registration status of the Safety Officer and Safety Manager must be included in the Safety Plan, and the Safety officer and Safety Manager will be on Site Full-time.
20	**Information for contractors**	State how information will be issued to contractors on site.
21	**Consultation/communication arrangements with Employees**	State how information will be given to employees e.g., notice board; toolbox talks and daily site task instructions (DSTI).
22	**Selection of Contractors Procedures**	The Principal Contractor must state what health and safety procedures they will use to assess the competence and resources of their contractors on Site.
23	**Activities with risk to Health and Safety (Risk Assessment)**	A Baseline Risk Assessment must be included in the Safety Plan, it must address the risks identified in the Safety Specification as well as the risk of any other hazards that the Principal Contractor is aware of that are relevant to the Site.
24	**Hazardous substances**	Must be listed in the Safety Plan and addressed in the Risk Assessment. Material safety data sheets to also be part of the plan.
25	**First aid and medical procedures**	Indicate name of first aider, training certificate, position of first aid box, location of nearest medical facility and emergency numbers.
26	**Fire and emergency procedures**	A list of emergency telephone numbers, the position of fire extinguishers, assembly point location, fire drill frequencies, numbers of fire marshals, etc. must be

No	Item	Notes
		included in the Safety Plan.
27	**Accident and incident reporting and investigation**	State the accident and incident reporting and investigation procedures of company.
28	**Welfare and site facilities**	Elaborate on toilets and eating areas, water provision, COVID-19 ablution provision, how will workers be protected during wet weather conditions etc.
29	**Site rules**	The Site rules must be included in the Safety Plan and displayed onsite.
30	**Personal Protective Equipment**	The necessity must be identified by risk assessments, the required PPE for site risks and COVID-19 control measures.
31	**Health & Safety file arrangements**	Indicate arrangements for the return of the Health and Safety file to the Safety Agent at the end of the project.
32	**Method Statements/Safe System of Works**	A list of Method Statements/Safe System of Works must be included in Safety Plan for all identified risk. Note that this is particularly relevant for Covid-19. No work may commence unless Covid-19 risks and control measures have been approved by the professional team.
33	**Permits and wayleaves**	List of activities that Principal Contractor anticipates will require permits and wayleaves (including those stated in the safety specification) to be included.
34	**Fall Prevention and Protection Plan and Fall Rescue Plan**	A copy of the Fall Prevention and Protection Plan, Fall Rescue Plan and Fall Risk Assessment must be included in the Safety Plan.
35	**Demolition Method Statement**	A copy of the Demolition Method Statement must be included in the Safety Plan.
36	**Confined spaces**	The Principal Contractors' procedures for managing access, egress and work in confined spaces must be specified in the Safety Plan, including permit procedures, air monitoring, PPE, etc.
37	**Safety Representatives and Safety Committees**	When a project has more than 20 employees a designated employee must be chosen by the labourers to represent them and appointed, trained as a SHE representative. A Safety Committee must be established if 2 or more Safety Representatives are appointed by the contractor including sub-contractors

No	Item	Notes
38	**Significant hazards from the Health and Safety Specification**	Practical measures to address these to be detailed in the Safety Plan.
39	**Covid 19 control measures from the Health & Safety Specification**	To be addressed. See below for Covid 19 control measures.
40	**Safety Policies in File and signed by 16(1) CEO.**	Safety Policies must be signed and explained to employees.
41	**Letter of Good standing**	A copy of the valid Letter of Good standing from FEM / Workman's Compensation must be on file.
42	**The 37.2 Mandatary Agreement**	A 37.2 Mandatary Agreement needs to be signed between the Client and the Principal Contractor and a copy must be on file.
43	**Appointment letter from Client (as well as 5.1.K)**	The Appointment Letter by the Client of the Principal Contractor to be on file.
44	**Notification / Permit**	A copy of the Annexure 2 Notification (and proof of submission) to Department of Labour must be available. This can be in the form of a department stamp, email, or copy of Construction Work Permit.

2.3.2 Covid 19 Control Measures

The following must be included by the contractors in their COVID-19 safety plan response (reference to contractors' employees / staff / workers / personnel on Site must include control of their (sub)contractors, visitors and suppliers):

a) Workplace Plan

A plan must be developed by the contractors for the phased in return of employees to site. Refer to the latest regulations and amendments, all persons who are able to work from home should do so.

b) Coordination on Site relating to COVID-19 matters

The contractor must appoint a manager to address employees concerns and keep them informed regarding COVID-19.

Additionally, the contractor must designate a COVID-19 compliance officer (required of all industries, businesses, entities, both private and in the public sector). This compliance officer is responsible for overseeing the following:

- Implementation of the workplace plan, and adherence to the standards of hygiene and health protocols relating to COVID-19 at the workplace;
- Developing a plan for the phased in return of their employees to the workplace, prior to reopening the workplace for business, which plan must correspond with Annexure E of the

Disaster Management Act 2002 (as amended April 2020) and be retained for inspection and contain the following information:

- which employees are permitted to work;
- what the plans for the phased-in return of their employees to the workplace are;
- what health protocols are in place to protect employees from COVID-19;
- the details of the COVID-19 compliance officer;
- phase in the return of their employees to work to manage the return of employees from other provinces, metropolitan and district areas; and
- measures to ensure that the workplace meets the standards of health protocols, adequate space for employees and social distancing measures for the public and service providers, as required.

c) Transportation to Site

Employees should be advised that if using transport, passengers must wear a cloth mask to be allowed entry into the vehicle. Hand sanitisers must be made available, and all passengers must sanitise their hands before entering. Public transport vehicles must be sanitised on a daily basis. Government mandated limit on passengers per vehicle must be strictly adhered to.

d) Site access

Entry to site may only be through pre-arranged security-controlled access points.

The Contractor must detail how members of public will be prevented from accessing site (risk of cross contamination between persons working on site and members of public).

A Visitors Book shall be provided for signing in and out of site. Records of all persons entering site and their contact details must be kept.

e) Screening on Site

The contractor to advise how personnel on site will be screened on a daily basis for symptoms of COVID-19, including a symptom check as well as temperature assessment (digital thermometer). The contractor must describe their procedure for employees on site, suspected of having COVID-19 symptoms, refusing to undergo medical examination, prophylaxis, treatment, isolation, and quarantine. Sites with more than 500 employees must have testing facilities.

f) Risk assessment and safety procedure

The contractor must provide a written policy concerning the protection of it staff from COVID-19. The contractor must compile a COVID-19 risk assessment and safety procedures for the site. How will it be communicated to all on site and records kept thereof.

The Risk Assessments must include the identification of exposure levels, identification of “high contact” activities, the identification of vulnerable workers and special measures for their protection, including protection against unfair discrimination or victimization.

g) Safety Signage and Hotline Number

The contractor to implement placement of COVID-19 safety signage and hotline number at site entrance and on site, warning of hazards and advising control measures. The signage must be representative of the local languages.

h) Communication Procedures

The contractor to describe comprehensive induction and toolbox talk procedures to include COVID-19. Toolbox talks should be conducted weekly on COVID-19 control measures and risks on site, include personal hygiene - manner of controlling coughing and sneezing on site - in elbow.

i) Emergency Procedure

The contractor must describe communication of COVID-19 symptoms and protocol that must be followed if a person demonstrates symptoms or is thought to have COVID-19 - symptoms of COVID-19 include cough, sore throat, shortness of breath or fever/chills (or ≥ 38°C measured temperature), redness of eyes, also additional symptoms – body aches, loss of smell or loss of taste, nausea, vomiting, diarrhoea, fatigue, weakness or tiredness. The contractor must advise personnel on site of the symptom reporting procedure to site management of COVID-19 symptoms, and referral protocol for screening or testing if showing symptoms.

Emergency COVID-19 protocol that must be put in place by the Principal Contractor must include:

- Sick workers may not enter workplace;
- If a sick worker is already on site, then the worker must be isolated in a designated area for isolation on site, provided with FFP1 surgical mask and transported for self-isolation or for medical examination or testing at a identified testing site;
- Worker placed on sick leave;
- On receiving their results, the employee and/or health professional supporting the employee should notify their workplace so that the employee is managed accordingly. The workplace should proactively take steps to obtain this information to avoid any delays in reporting;
- Assess the risk of transmission, disinfect area and workers workstation, refer exposed workers for screening, etc.;
- Lodge claim with Workman’s Compensation if infection occupationally acquired;
- Worker may only return to work after undergoing a medical evaluation confirming worker has tested negative for COVID-19;
- Worker must be closely monitored for symptoms on return to work; and
- If workers have been diagnosed with COVID-19, their employer must notify the Department of

Health and the Department of Employment and Labour.

Personnel on site, or presenting themselves to site who appear sick, or have symptoms associated with COVID-19, may not be allowed on site.

j) Welfare and Washing Facilities, Sanitising and Disinfection

The contractor must provide soap, clean running water and sanitisers at the site entrances and at other locations on site, with signage of correct manner of washing / disinfecting hands, e.g. 20 second rule. Use of paper towels only shall be allowed. Disinfection of work surfaces and equipment control procedures are required - carried out before work begins, regularly during day and after work ends. Toilets, common areas, door handles, shared electronic equipment and any other shared equipment must be regularly cleaned and disinfected, biometric systems disabled or made COVID-19 safe.

Hand sanitiser must contain 70% alcohol.

Employees working away from home should be provided with hand sanitiser by the employer.

k) COVID-19 PPE on Site

The contractor must describe controls for wearing of PPE on site, including cloth masks and people working and visiting site must be instructed on the correct way of wearing cloth masks, including procedure for maintenance and replacement of cloth masks. Surgical masks and N95 masks should only be worn by frontline health workers, not site staff. Note that some surgical masks should be kept on site to give to persons exhibiting COVID-19 symptoms prior to being taken away for testing.

Each employee shall be provided with at least 2 cloth masks and appropriate arrangements must be made for washing, drying and ironing of cloth masks.

l) Supervision and Monitoring on Site

Monitoring systems must be in place by the contractor to ensure compliance with safety protocols and identify infections among employees - supervision monitoring and enforcement - how will it be done by the contractor?

m) Ventilation on Site

Methods how ventilation and air quality will be made safe on site.

n) Waste Management

Sufficient refuse bins must be on site for disposal of tissues and used PPE. Procedure for safe removal of contents of bins; used PPE, other detritus should be made in the contractors safety plan.

o) Social Distancing Measures

The contractor must describe, so far as practicable how can numbers of workers be minimised on site at any one time, e.g. through staff rotation, staggered working hours, shift systems, remote working arrangements or similar to achieve social distancing (1.5m). The contractor must minimise contact between workers themselves and workers and public.

Depending on what is reasonably practicable, the site must be arranged so that there is distance of at least 1.5m between workers and members of public or physical barriers shall be put in place or provide workers with face shields or visors.

p) COVID-19 Investigation procedure

The contractor must describe how they will investigate the cause of COVID-19 infection (including control failure and risk assessment review, checking of PPE requirements, admin support to contact tracing implemented by Dept of Health).

If more than 500 employees in the contractor's employment, the employer must submit this risk assessment and written policy regarding health and safety of employees from COVID-19 to the Safety Committee and Department of Employment and Labour.

Monitoring by the Safety Agent will be strict - noncompliance with COVID-19 control measures will be reported immediately to the Principal Contractor for action. If necessary, transgressors will be removed from site for re-induction, or a recommendation for permanent barring from site will be made.

As this is an ongoing medical crisis it is likely that control measures to prevent the spread of the virus will be updated by the government on a regular basis. Hence the measures in this section of the safety specification could change and contractors shall comply with updated measures as received from government on an ongoing basis.

2.3.3 Other information

The OH&S file shall also include the following information, as a minimum:

a) Notification of Construction Work (Construction Regulation 4) (Schedule A);
b) Copy of the OH&S Act (updated) (General Administrative Regulation 4);
c) Copy of the COID Act (updated);

d) Copy of the MH&S Act (updated);
e) Proof of Registration and good standing with a licensed compensation insurer or the Compensation Commissioner (Construction Regulation 7(1)(c)(iv));
f) Copy of the this OH&S Specification (Construction regulation 5(1)(a));
g) Copy of the OH&S Plan (Construction regulation 7(1));
h) The Principal Contractor's company SHE Policy;
i) A record of designs/drawings and materials to be used in the Contract (Construction Regulation 11(1)(c));
j) The legal compliance and Site audit system that will be in use by the Principal Contractor;
k) Monthly and other occupational health and safety reports to the Client;
l) Copies of reports to the Department of Labour, the compensation insurer and other parties and authorities;
m) Copies of incident investigation reports;
n) Incident experience reports, statistics and graphs;
o) Reports by the health and safety representatives;
p) Minutes of the health and safety committee/s meetings;
q) A list of contractors including copies of the OH&S Act Section 37(2) and other agreements between the parties and the type of work being done by each contractor (Construction Regulation 7);
r) Appointment / designation forms required by the OH&S Act and its regulations together with the proof of the appointees' competence, as follows:
    - Assistant to the Contractor's Chief Executive Officer (OH&S Act Section 16(2));
    - Construction Manager (Construction Regulations 8(1));
    - Construction Supervisor (Construction Regulation 8(7));
    - Assistant Construction Supervisors (Construction Regulation 8(8));
    - Construction Health and Safety Officer/s (Construction Regulation 8(5));
    - Construction Health and Safety Manager;
    - Traffic Safety Officer;
    - Occupational Health and Safety Representatives (OH&S Act Section 17);
    - Members of the Occupational Health and Safety Committee/s (OH&S Act Section 19);
    - Temporary work Designer (Construction Regulation 12(1));
    - Temporary work Supervisor (Construction Regulation 12(2));
    - Construction Risk Assessor (Construction Regulation 9(1));
    - Scaffold Supervisor (Construction Regulation 16(1));
    - Scaffold Inspector (Construction Regulation 16(1));
    - Scaffold Team Leader (Construction Regulation 16(1));
    - Scaffold Erector (Construction Regulation 16(1));
    - Suspended Platform Supervisor (If applicable) (Construction Regulation 17(1));
    - Material Hoist Inspector (Construction Regulation 19(8)(a));
    - Material Hoist Operator (Construction Regulation 19(6));
    - Incident Investigator (General Administrative Regulations 9(2));

- Person responsible for machinery (General Machinery Regulation 2(1));
- Bulk Mixing Plant Supervisor (Construction Regulation 20(1));
- Bulk Mixing Plant Operator (Construction Regulation 20(2));
- Construction Vehicle and Mobile Plant Supervisor/Controller (Construction Regulation 23);
- Construction vehicle and mobile Plant drivers and operators (Construction Regulation 23(1)(d)(i));
- Demolition Supervisor/Controller (if applicable) (Construction Regulation 14(1));
- Electrical Installation Supervisor (Construction Regulation 24);
- Fire & Emergency Coordinator (Construction Regulation 29);
- Fire Extinguishing Equipment Inspector (Construction Regulation 29(h));
- Excavation Supervisor (Construction Regulation 13(1)(a));
- Controller of Explosive Actuated Fastening Devices Nails, Cartridges or Studs Issue and Collection (Construction Regulation 21 (2)(g)(1));
- Explosives Manager (Explosives Regulations 12(1));
- Explosives Supervisor (Explosives Regulations 12(3));
- Fall Protection Supervisor (Construction Regulation 8(1));
- Fall Protection Plan Developer (Construction Regulation 10(1)(a));
- First Aider/s (General Safety Regulation 3 (4));
- Hazardous Chemical Agents Supervisor (Hazardous Chemical Agents Regulations)
- Stacking, Storage and Good Housekeeping Supervisor (Construction Regulation 28(a) & Construction Regulation 27);
- Ladder Inspector (General Safety Regulation 13A);
- Lifting Machines and Equipment Supervisor (Driven Machinery Regulations 18);
- Pipe Jacking Supervisor (if applicable) (Construction Regulation 15 & Construction Regulation 23);
- Pressure Equipment Supervisor (Pressure Equipment Regulations);
- Welding Supervisor (General Safety Regulation 9);
- Working on or Near Water Supervisor (Construction Regulation 26);
- Borrow pit Supervisors (Mine Health & Safety Act);
- Confined space competent person (General Safety Regulation 5(1)); and
- COVID 19 – Compliance Officer and COVID 19 – Manager (to address employees concerns and keep them informed re COVID-19)

s) The appointees listed above shall keep some written record of their activities, which shall be included in the OH&S file. This record shall include:

- Audit and inspection reports by the assistant to the Chief Executive Officer, the construction work supervisor and his/her assistants, the safety officer/s, the occupational health and safety representatives and other senior staff of the contractor that may conduct health and safety audits and inspections;
- An index/schedule of Risk Assessments and Method Statements together with the Risk Assessments and Method Statements developed as well as the review programme for these;
- Accident / incident register (Annexure 1 of the General Administrative Regulations);

- An index/schedule of accidents/incidents experienced;
- Copies of accident and incident reports;
- Schedule of mechanical and electrical machinery used on Site together with their inspection registers and maintenance records;
- Batch Plant inspection register;
- Schedule of construction vehicles and mobile Plant used on Site together with their inspection registers and maintenance records;
- Demolition Method Statement, daily inspection register and, where explosives are to be utilised, the necessary permits and other documentation;
- Electrical certificate/s of compliance and monthly inspection register;
- Emergency contingency plan and practice/drill programme;
- Fire equipment inspection register/s;
- Daily excavation inspection register/s;
- Explosive powered tool inspection and maintenance register (if applicable);
- Fall protection plan including the programme for training persons who work in fall risk positions and the maintenance programme and inspection register for the fall arrest equipment used on Site;
- First aid box checklist and dressing register/s;
- Formwork and support work permits to pour/strip concrete and inspection register/s;
- The training programme for persons handling formwork and support work components whilst erecting and dismantling:
  - Access and support scaffolding inspection register/s.
- The training programme for persons handling scaffolding components whilst erecting:
  - Hazardous chemical substances schedule (including index of MSDS's) stored/used on Site;
  - Daily stacking/storage/good housekeeping inspection register;
  - Weekly ladder inspection register;
  - Lifting machines and equipment maintenance and inspection records;
  - Traffic supervisor daily inspection register;
  - Tunnelling supervisor daily inspection register;
  - Vessels under pressure maintenance and inspection records;
  - Welding supervisor daily inspection register;
  - Working on or near water plan and inspection register;
  - Designer's inspection of structures record; and
  - The contractor's health and safety officers' programme for promoting health & safety throughout the whole construction period.

t) The health and safety training programme for the project; and

u) Any other matters that need to be included in terms of the OH&S Act and this Section.

The Health and Safety File shall be handed over to the Client on completion of the Contract. It must contain all documentation handed to the Principal Contractor by any contractors together with a

record of all drawings, designs, materials used and other similar information concerning the completed Contract.

2.4 RISK ASSESSMENTS

The contractor shall, before the commencement of any construction work or work associated with the aforesaid construction work and during such work, ensure that a Risk Assessment is undertaken by a competent person, appointed in writing, and the Risk Assessment shall form part of the occupational health and safety plan and be implemented and maintained as contemplated in Construction Regulation 5(1).

The Risk Assessment shall include at least:

i) Identification of all risks and hazards in the Contract;
ii) Analysis and evaluation of the risks and hazards identified;
iii) A documented plan of safe work procedures;
iv) A monitoring plan; and
v) A review plan.

In order to ensure compliance with the Construction Regulations, the contractor will be required to carry out the following three forms of Risk Assessment:

2.4.1 Baseline or Datum Risk Assessments

A Risk Assessment before the commencement of construction activities. This “baseline” or “datum” Risk Assessment will form part of the contractor’s health and safety plan. The risks and hazards to which persons, plant, vehicles and facilities may be exposed during the construction should be identified and evaluated. Measures to reduce or control these risks or hazards should be defined during this assessment. The effectiveness of the measures defined and the baseline Risk Assessment prepared shall be monitored and reviewed from time to time to ensure that it remains relevant and accurate.

Please refer to the Baseline Risk Assessment in Schedule E.

2.4.2 Issue Based Risk Assessments

The Contractor will be required to carry out separate Risk Assessments during construction of the Works when methods and procedures are varied, for example when:

a) Designs are amended;
b) New machines are introduced;
c) Plant is periodically cleaned and maintained;
d) Plant is started-up or shut-down;
e) Systems of work change or operations alter;
f) Indents or near-misses occur; or
g) Technological developments invalidate prior Risk Assessments.

2.4.3 Continuous Risk Assessments

The OH&S Act specifically requires that employers shall provide and maintain working environments that are safe and without risk to health. The general awareness of hazards needs to be raised as work ethic to maintain a safe and risk-free environment on an on-going basis. This is achieved by continuous Risk Assessments, the most important form of Risk Assessment that takes place as an integral part of day-to-day management.

Examples of continuous Risk Assessments include:

- Regular audits;
- Maintaining general hazard awareness; and
- Pre-work Risk Assessment.

In addition, the Principal Contractor shall ensure that all contractors conduct Risk Assessments for their scope of work. These shall be placed in the Principal Contractor's OH&S file and form part of the Risk Assessments of the Contract.

The Risk Assessments shall identify and evaluate the risks and hazards that may be expected during the execution of the Works and shall include a documented plan(s) of safe work procedures to mitigate, reduce or control the risks and hazards identified.

The Risk Assessment shall be available on Site for inspection by inspectors, Client, Client's Agents, contractors, employees, trade unions and OH&S committee members, and must be monitored and reviewed periodically by the contractor.

The contractor shall, emanating from the Risk Assessments, the requirements of this Section, the OH&S Act and its Regulations and other applicable legislation and standards compile a set of OH&S rules for the Site which rules shall be applied on Site and included in induction and other training.

Safe work procedures to be drafted for all risks identified by the contractor. Safe work procedures to from part of the file and be reviewed and updated on a regular basis or a risk has changed. The procedures to be communicated to all employees before the task at hand is executed.

2.5 AUDITS

The Principal Contractor's Safety Officer, Safety Manager and Site Management will be responsible for the auditing of the implementation of the Health and Safety Specification and maintaining the document control and record systems associated with the Health and Safety Specification.

The Client will arrange for health and safety audits to be conducted on Site on their behalf (Construction Health & Safety Agent) to monitor health and safety compliance by contractors.

The results and details of these audits by the Safety Officer, Safety Manager and Safety Agent shall

be submitted to the Engineer/Client within 7 days of the date of the audit. Although the pro-forma questionnaire/checklist to be used is given in Schedule C of this Section, the contractor shall ensure that the format used contains all the elements in the Contractor's OH&S Plan that need to be audited.

The Safety Agent will monitor compliance by the contractor with the OH&S Plan by means of monthly (minimum) independent audits and may give instructions for improvements or stop the work as required by Construction Regulation 5(1)(q). The Client reserves the right to conduct other ad hoc audits and inspections as deemed necessary.

The Safety Agent may, as considered necessary, carry out combined audits with the contractor's auditor.

2.6 APPOINTMENT OF CONTRACTORS

2.6.1 Provision of Applicable Information and Documents

The Principal Contractor shall:

- Provide contractors to perform construction work for the Principal Contractor, with the relevant sections of the health and safety specifications pertaining to the construction work which has to be performed;
- Ensure that potential contractors submitting tenders have made sufficient provision for health and safety measures during the construction process;
- Ensure that no contractor is appointed to perform construction work unless the Principal Contractor is reasonably satisfied that the contractor has the necessary competencies and resources to perform the construction work safely;
- Ensure prior to work commencing on the site that every contractor is registered and in good standing with the compensation fund or with a licensed compensation insurer as contemplated in the Compensation for Occupational Injuries and Diseases Act, 1993;
- Appoint each contractor in writing;
- Take steps to ensure that each contractor's health and safety plan is implemented and maintained on the construction site;
- Ensure that the periodic site audits and document verification are conducted at intervals mutually agreed upon between the Principal Contractor and any contractor, but at least once every 30 days;
- Stop any contractor from executing construction work which is not in accordance with the Client's health and safety specifications and the Principal Contractor's health and safety plan for the site or which poses a threat to the health and safety of persons;
- Where changes are brought about to the design and construction, make available sufficient health and safety information and appropriate resources to the contractor to execute the work safely;
- Discuss and negotiate with the contractor the contents of their health and safety plan and finally approve that plan for implementation;

- Ensure that a copy of both the Principal Contractor and contractor's health and safety plan is available on request to an employee, an inspector, a contractor, the Client, or the Client's Safety Agent;
- Hand over a consolidated health and safety file to the Client upon completion of the construction work, to include a record of all drawings, designs, materials used and other similar information concerning the completed structure;
- In addition to the documentation required in the health and safety file, include and make available a comprehensive and updated list of all the contractors on site accountable to the Principal Contractor, the agreements between the parties and the type of work being done; and
- Ensure that all the employees have a valid medical certificate of fitness specific to the construction work to be performed and issued by an occupational health practitioner in the form of Annexure 3 (a template of which can be found in the Construction Regulations, 2014).

A contractor must prior to performing any construction work:

- Provide and demonstrate to the Principal Contractor a suitable and sufficiently documented health and safety plan, based on the relevant sections of the Client's health and safety specification, which plan must apply from the date of commencement and for the duration of the construction work and which must be reviewed and updated by the contractor as work progresses;
- Open and keep on site a health and safety file, which must include all documentation required in terms of the Act and these Regulations, and which must be made available on request to an inspector, the Client, the Client's Safety Agent or the Principal Contractor;
- Before appointing another contractor to perform construction work be reasonably satisfied that the contractor has the necessary competencies and resources to perform the construction work safely;
- Co-operate with the Principal Contractor as far as is necessary to enable each of them to comply with the provisions of the Act; and
- As far as is reasonably practicable, promptly provide the Principal Contractor with any information which might affect the health and safety of any person on the site, any person who might be affected by the work of such a person at work, or which might justify a review of the health and safety plan.

Where a contractor appoints another contractor to perform construction work, the same duties that apply to the Principal Contractor will apply to the contractor.

A Principal Contractor must take reasonable steps to ensure co-operation between all contractors appointed by the Principal Contractor to enable each of those contractors to comply with these Regulations.

A contractor must at all times keep on his or her construction site records of the health and safety induction training and such records must be made available on request to an inspector, the Client, the Client's Safety Agent or the Principal Contractor.

A contractor must ensure that all his or her employees have a valid medical certificate of fitness specific to the construction work to be performed and issued by an occupational health practitioner in the form of Annexure 3.

2.6.2 H&S Induction Training (Construction Regulations 7 and 8)

The Principal Contractor shall ensure that all persons under his control, including his own employees, visitors and contractors and their employees, undergo appropriate OH&S induction training courses by (a) competent person(s) before entering the Site or commencement of construction work and no employee, Contractor or visitor shall be allowed to enter the Site of the Works without prior OH&S induction training and the necessary the necessary personal protective equipment.

The Contractor shall ensure that every employee or visitor on Site shall at all times be in possession of proof of completing the OH&S induction training by a competent person.

2.6.3 OH&S Training Requirements

The Principal Contractor shall undertake training as follows (As required by the Construction Regulations, 2014 and as indicated in this Section and the Risk Assessment/s undertaken by the Principal Contractor):

a) General Induction (Section 8 of the Act);
b) Site/Job Specific Induction (also visitors) (Sections 8 and 9 of the Act);
c) Construction Manager and his/her assistants;
d) OH&S Representatives (Section 18(3) of the Act);
e) Training of the Appointees listed above;
f) Operators of Cranes (Driven Machinery Regulations 18(11));
g) Operators and Drivers of Construction Vehicles and Mobile Plant (Construction Regulation 23);
h) Basic Fire Prevention and Protection (Environmental Regulations 9 and Construction regulation 29);
i) Basic First Aid (General Safety Regulations 3);
j) Storekeeping Methods and Safe Stacking (Construction Regulation 28);
k) Emergency, Security and Fire Co-ordinator; and
l) Weekly toolbox talks for all employees.

2.7 APPOINTMENT OF OH&S PERSONNEL

The Principal Contractor shall appoint competent persons as per the list in Clause 2.3.

2.7.1 Construction Manager

A Principal Contractor must, in writing appoint one full-time competent person as the construction manager with the duty of managing all the construction work on a single site, including the duty of ensuring occupational health and safety compliance, and in the absence of the construction manager an alternate must be appointed by the Principal Contractor. Proof of all-inclusive assessment of the construction manager's competency in construction management and H & S competency must be available in the Safety File. The construction manager must, as a minimum, have completed a Construction Regulations course.

No contractors may be left unsupervised on site by the Principal Contractor.

A Principal Contractor must upon having considered the size of the project, in writing appoint one or more assistant construction managers for different sections thereof, provided that the designation of any such person does not relieve the construction manager of any personal accountability for failing in his or her management duties in terms of this regulation.

Where the construction manager has not appointed assistant construction managers, or, in the opinion of an inspector, a sufficient number of such assistant construction managers have not been appointed, that inspector must direct the construction manager in writing to appoint the number of assistant construction managers indicated by the inspector.

No construction manager appointed in terms of the Regulations may manage any construction work on or in any construction site other than the site in respect of which he or she has been appointed.

A construction manager must in writing appoint construction supervisors responsible for construction activities and ensuring occupational health and safety compliance on the construction site. Proof of all-inclusive assessment of the construction supervisor's competency in construction supervision and H&S competency must be available in the Safety File. The construction supervisor must, as a minimum, have a supervision course as per Unit Standard 262845 (Civil Engineering), 119080 (Building Construction) and 262884 (Civil Engineering).

A contractor must, upon having considered the size of the project, in writing appoint one or more competent employees for different sections thereof to assist the construction supervisor, and every such employee has, to the extent clearly defined by the contractor in the letter of appointment, the same duties as the construction supervisor, provided that the designation of such employee does not relieve the construction supervisor of any personal accountability for failing in his or her supervisory duties.

Where the contractor has not appointed such an employee, or, in the opinion of an inspector, a sufficient number of such employees have not been appointed, that inspector must direct the contractor in writing to appoint the number of employees indicated by the inspector.

No construction supervisor appointed may supervise any construction work on or in any construction site other than the site in respect of which he or she has been appointed, provided that if a sufficient number of competent employees have been appropriately designated on all the relevant construction sites, the appointed construction supervisor may supervise more than one site.

2.7.2 Health & Safety Officer and Safety Manager

A Principal Contractor must, after consultation with the Client and having considered the size of the project, the degree of danger likely to be encountered or the accumulation of hazards or risks on the site, appoint a full-time construction health and safety officer (Safety Officer) and manager in writing to assist in the control of all health and safety related aspects on the site: Provided that, where the question arises as to whether a Safety Officer is necessary, the decision of an inspector is decisive.

No contractor may appoint a Safety Officer or Safety Manager to assist in the control of health and safety related aspects on the site unless the person is registered with a statutory body approved by the Chief Inspector, has the necessary competencies and resources to assist the contractor and is professionally registered with the SACPCMP. Proof of registration with the SACPCMP must be provided.

2.7.3 OH&S Representatives

In terms of Sections 17 and 18 of the OH&S Act, the Contractor shall appoint OH&S Representatives.

The number of OH&S Representatives shall be at least one for every 50 employees.

The OH&S Representatives must be selected from employees who are employed in a full-time capacity on the Site and who have received the necessary training to enable them to carry out their specified OH&S duties.

The functions of the OH&S Representatives will be:

a) To review the effectiveness of OH&S measures;
b) To identify potential hazards and incidents which may develop;
c) To examine causes of incidents;
d) To investigate complaints by employees relating to OH&S at work;
e) To make representations to the Client or an inspector of the Department of Labour on matters affecting the OH&S of employees;
f) To inspect the workplace, plant, machinery etc. on a regular basis; and
g) To participate in inspections or consultations with Department of Labour inspectors.

2.7.4 Occupational OH&S Committee

The Principal Contractor shall establish one or more OH&S Committee(s) in terms of Section 19 of the OH&S Act and select persons to serve on the committee(s) in writing.

Attendance of meetings of the OH&S Committee(s) will be compulsory for all OH&S Representatives of all contractors whilst on Site.

The committee(s) shall comprise:

- The OH&S Manager;
- The OH&S Chairperson;
- The OH&S Representatives;
- Representatives of the Principal Contractor's supervisory staff;
- Representatives of the contractors present on Site;
- A member of the Engineer's staff nominated by the Engineer; and
- Any other person nominated by the Client.

The contractor's obligations and liabilities in respect of health and safety matters shall not be limited or affected in anyway by the inclusion, in the committee, of a member of the Engineer's staff or Client's Agents.

The main functions of the OH&S Committee will inter alia be:

a) To review health and safety procedures for the purposes of monitoring effectiveness or short comings and to recommend changes to the procedures where necessary;
b) To review the inspection reports of the OH&S Representatives and make recommendations where necessary;
c) To review incident reports and make recommendations as to what steps may be taken to prevent similar incidents in future;
d) To carry out regular inspections, review results and make recommendations where necessary;
e) To investigate any unsafe practices;
f) To review, consider and report on any aspect of health and safety contained in this Section or any other part of the Contract;
g) To consider any health and safety matter brought to its attention by an OH&S Representative or other employee, and
h) To maintain a written record of all meetings of the Committee.

The Committee shall meet at least at monthly intervals. Minutes of meetings shall be kept by the Principal Contractor and copied to the Client and Engineer within 7 days of the meeting.

2.7.5 Competent Persons

All persons appointed in accordance with this Section shall be competent and proof of their competence shall be held, together with the written appointment, on the OH&S File. The File shall contain a complete list of the appointees described here.

Proof of competence shall be a combination of certified copies of qualifications, written, certified proof of experience and a certified copy of the person's CV.

A competent person may be appointed for more than one aspect of the construction work on the understanding that the person must be suitably qualified and able to supervise, at the same time, the construction work on all the work situations for which he/she has been appointed.

The appointment of competent persons to supervise parts of the construction work does not relieve the Principal Contractor from any of his responsibilities to comply with all requirements of this Section.

2.8 PRINCIPAL CONTRACTOR'S OH&S RESPONSIBILITIES

2.8.1 General

Before commencement of any work under the Contract, the Principal Contractor shall enter into an OH&S Act Section 37(2) Agreement with the Client to confirm his status as mandatory for the Contract.

The Contractor's duties and responsibilities are as set out in the Construction Regulations. Although some important aspects are repeated below, this does not relieve the Contractor of any of his duties and responsibilities in terms of the Construction Regulations.

In addition, the Contractor shall submit a current letter of good standing with the Compensation Insurer or Compensation Commissioner to the Client before work on Site commences and maintain his status of good standing throughout the contract period.
In order to give effect to Construction Regulation 5, the Principal Contractor shall liaise closely with the Client and the Engineer and the Safety Agent to ensure that all requirements of the OH&S Act and its Regulations are met and complied with.
Neither the Client, the Engineer nor the Client’s Agents appointed in terms of Construction Regulation 5(5) or 5(6), will occupy the role or accept the duties and responsibilities of the responsible persons appointed by the Principal Contractor for the various aspects listed in Clause 2.3 above.

2.8.2 The Principal Contractor and Contractors (Construction Regulation 7)

The relationship between the Principal Contractor and his contractors shall be as set out in Regulation 7.

All contractors shall prepare an OH&S Plan in terms of Regulation 7 before commencement of the work which plan shall be kept in the OH&S File.

Any contractors employed by the Principal Contractor shall be appointed in writing, which appointment shall, inter alia, set out the terms of the appointment in respect of OH&S.

The Principal Contractor’s OH&S Act Section 37(2) Agreement with every contractor shall be kept in the Principal Contractor’s OH&S File.

Notwithstanding any arrangements between the Principal Contractor and contractors, all contractors will be responsible for the OH&S of persons employed by them and any other person affected by their work activities.

2.8.3 Risk Assessment (Construction Regulation 9)

The Risk Assessor shall be responsible for ensuring the required Risk Assessments are developed, reviewed and updated on a continued basis.

The Principal Contractor shall have a baseline and issue-based Risk Assessments performed as set out in Regulation 9 before commencement of the work and these must be available on Site for inspection at all times.

The Risk Assessor shall consult with the OH&S committee and OH&S representative(s) on a regular basis to ensure that all employees, including contractors, are informed and trained by a competent person regarding health hazards and related work procedures.

2.8.4 Accident/Incident Investigation and Reporting (OH&S Act Section 24 and General Administrative Regulations 8 and 9)

2.8.4.1 Reporting of Infringements, Improvements, Incidents, Hazards

a) The Principal Contractor's procedures for the reporting of health and safety infringements, improvements, incidents, hazards and the like shall be kept in the OH&S File. The Principal Contractor shall act on these reports as soon as reasonably practical. The Principal Contractor shall ensure that these reporting procedures are explained and complied with by all contractors on the Site.
b) The Principal Contractor is responsible for the investigation of all accidents/incidents where employees and non-employees are injured to the extent that he/she/they have to be referred for medical treatment to a doctor, hospital or clinic.
c) The results of all investigations are to be entered into the Accident/Incident Register (Annexure 1 in the OH&S Act).
d) The Principal Contractor shall investigate of all minor and non-injury incidents as described in Section 24(1)(b) and (c) of the Act as well as all road traffic accidents and keep a record of the results of such investigations in the OH&S File, including the steps taken to prevent similar accidents from recurring.
e) The Client reserves the right to hold its own investigation into any incident or call for an independent external investigation.
f) With reference to General Administrative Regulation 8, the Principal Contractor shall report all named incidents where an employee is injured on duty to the Client within two days and to the Provincial Director of the Department of Labour within seven days except that, where a person has died, has become unconscious for any reason or has lost a limb or part of a limb or may die or suffer a permanent physical defect, the incident shall be reported forthwith by telephone, facsimile or email.

g) Copies of all statutory reports and all internal and external accident/incident investigation reports shall be supplied to the Client and the respective employer and kept in the OH&S File by the Principal Contractor.

h) The Principal Contractor shall keep the Engineer and Safety Agent advised of any occurrence during the course of work, whether on or off the Site, if the said occurrence affected or may have affected the health or safety of any person employed on the Site or of any member of the public.

i) The Principal Contractor shall submit to the Engineer and Safety Agent in electronic format and hard copy, at the end of each month, reports and statistics in spreadsheet format approved by the Safety Agent on all accidents/incidents involving any person that was injured, or material or equipment damaged or lost, or where there was a realistic likelihood of this occurring.

2.8.4.2 Statistical Information for Each Month

Statistical information to be submitted each month by the Principal Contractor shall include at least:

- The Compensation Claim frequency rate (No. of Compensation Claims X 100 000/Hours worked);
- The *Disabling Injury Frequency Rate (DIFR) (No. of Disabling Injuries X 100 000/hours worked);
- First aid only injuries;
- Damage or loss incidents; and
- No injury, damage or loss incidents.

*****" Disabling Injury": The injured workman does not return to work on the next day or shift.

Before the issue of the Taking Over Certificate, or earlier if requested by the Safety Agent, the Contractor shall furnish the Safety Agent with a full report summarising the statistical returns for OH&S incidents during the Contract, as part of the OH&S File.

2.8.5 Employees' Health and Proof of Medical Fitness

The Principal Contractor shall institute and operate a medical screening and examination system for prospective employees that shall be submitted for review by the Safety Agent and be in accordance with requirements of the Department of Health and the Department of Labour (Refer to the Annexure 3 - Medical Certificate of Fitness, as required by the Construction Regulations 7(1)(g) 2014). The results of the examination prior to employment shall form the employee's baseline medical condition.

Screening and medical examination shall take place before employment, annually and on termination of employment. Medical records are required by the OH&S Act to be kept for forty years.

The initial screening before employment may be dispensed with if the person to be employed presents a medical certificate of fitness issue by an occupational medical practitioner that covers those aspects required for the work for which the person is being employed.

The examination system shall include the requirement that all persons, in terms of Noise Induced Hearing Loss Regulation (NIHLR) 8(2), on employment, shall undergo a hearing test in accordance with the applicable SANS standard with a baseline audiogram for that person as the result. The hearing test is to be repeated annually and finally when the employee leaves the employer for whatever reason. The employee is to be given a copy of the audiogram on leaving.

The following conditions may lead to work related disorders and shall be treated as stated (the items below are not comprehensive and not all-inclusive):

2.8.5.1 Noise Induced Hearing Loss (NIHL Regulations)

Where noise exceeds 85 dB(A), the following shall be provided:

a) Proof of training required by the NIHL regulations;
b) The Risk Assessment done within 1 month of commencement of work;
c) The programme for monitoring carried out by a Department of Labour, Occupational Hygiene Approved Inspection Authority and done according to SANS 10083;
d) Medical surveillance programme established and maintained for the affected employees;
e) Method by which records are going to be kept for 40 years; and
f) In addition, the Contractor shall:
    i) Endeavour to lower the noise to less than 85 dB(A) as a first priority;
    ii) Provide exposed workers with ear plugs where the noise is > 84 dB(A) but < 95 dB(A); and
    iii) Provide the exposed workers with earmuffs where the noise level is > 95 dB(A).

2.8.5.2 Dust and Fumes (including Silica and Cement) Exposure (Environmental Regulations for Workplaces)

The Principal Contractor shall engage, annually, the services of a Department of Labour accredited approved inspection authority for Occupational Hygiene to measure the exposure by workers to dust and/or fumes.

Where the exposure exceeds the levels as prescribed in the Environmental Regulations for Workplaces the Contractor shall:

- As a first priority extract or ventilate the workplace so as to lower the levels of dust and/or fumes to an acceptable level; and
- Provide suitable respirators to protect exposed workers against the inhalation of harmful dust and/or fumes.

The Contractor shall annually have all employees examined for chest diseases such as tuberculosis by a screening agency, accredited by the Department of Health.

2.8.5.3 HIV and Aids

The contractor shall maintain an active anti-HIV and Aids programme in conjunction with local NGO's.

2.8.5.4 Allergy Conditions

The screening as contemplated above shall include gleaning information of allergies suffered by workers exposed to agents used and encountered in the workplace e.g., special coatings applied to the pipeline etc.

Comprehensive records shall be kept in the OH&S File of employees non-confidential medical records such as visits to medical practitioners, treatments etc.

2.8.5.5 Epidemics and pandemics

In the event of any outbreak of illness of a highly contagious or epidemic or pandemic nature the contractor shall comply with and carry out such regulations, orders and requirements as may be made by the relevant authorities, and in particular the COVID-19 legislation protocols and guidelines.

2.8.6 Promotion of Health and Safety in the Workplace

The Principal Contractor shall promote the need for safety awareness in all aspects of the work by conducting weekly Toolbox Talks, safety awareness programmes and campaigns, and training throughout the duration of construction work, displaying posters and using audio visual methods.

2.8.7 Non-compliance with the Construction Regulations 2014

The Principal Contractor shall ensure that all provisions of the Construction Regulations applicable to the Contract are complied with to.

Failure by the Principal Contractor to comply with safety requirements will entitle the Safety Agent to order a temporary halt of work within the affected areas until the specified requirements are met, without any extension of time being granted and without any additional payment.

2.9 CONTRACT SPECIFIC REQUIREMENTS

2.9.1 Existing Environment

The contractor shall implement health and safety measures and precautions for the following:

- Members of the public;
- Pedestrian and vehicle traffic;
- Agricultural business operations, activities, vehicle and equipment movement, personnel movement, internal farm roads, etc.:
- Possible crime & protest action;
- Fire risk due to construction activities or started/self-started veld fires;

- Overgrown vegetation including trees found near water channels;
- Covid 19 exposure;
- Contact with snakes and/or poisonous insects;
- Free roaming livestock and wildlife;
- Sensitive environmental and ecological areas including protected & endangered wildlife;
- Existing Services;
- Recreational areas;
- Water bodies, river areas and wetland/flood plain areas;
- High subsurface water table;
- Flooding; and
- Movements of earth, rock, boulders etc. during operations.

The Principle Contractor shall ensure that the following are in place before commencement of work:

- Wayleaves, permits and isolations at existing services;
- Permission from land owners

The following are specific activities and considerations that have been identified for the Contract and for which Risk Assessments, Standard Working Procedures (SWP), management and control measures and Method Statements (where necessary) shall be developed by the Contractor:

2.9.2 Significant Health and Safety Hazards identified by Client, Designer and Safety Agent

a) Snakes, poisonous insects and wildlife

A qualified first aider with knowledge of emergency treatment of snake and poisonous insect bites and the appropriate medical kits to be on site. Precautions such as checking out area before working are required. Details of nearest hospital and emergency telephone numbers to be available.

Wildlife protocols to be in place, also considering larger animals, i.e., baboons, e.g. do not feed - do not litter – left over food may attract aggressive interactions.

b) Members of the public and road traffic and traffic management

For existing roads, agricultural land, wetlands, rivers, dam areas, safety issues regarding risks to surrounding agricultural operations, members of public, road traffic and animals shall be attended to.

The health and safety of members of public and road users must be a priority at all times and all necessary steps must be taken to prevent unauthorised entry to site and to protect members of the public from any dangers associated with the construction works being undertaken.

Existing roads will remain open during works with more detailed description contained in the Traffic

Management Plan. This is a critical hazard to traffic/members of public and to workers who must have high visibility clothing on at all times. Safety of road users and workers is crucial and must be addressed in the Traffic Management Plan to be compiled by the Principal Contractor for review by the Safety Agent and Engineer. The Principal Contractor is responsible for the following, but not limited to:

- Directional signage or stop-go or possible traffic diversion to divert pedestrian members of the public and road users. All flag persons to control traffic with red flags and to have high visibility clothing on at all times;
- Personnel operating Stop/Go control points are to be protected from being struck by oncoming vehicles with concrete Jersey Barriers; and
- Road marking teams are to be protected by a leading-edge vehicle to warm oncoming traffic during road painting operations.

c) Hot works

All hot works will require a Method Statement. A permit to use equipment is required after it has been inspected and found to be in good condition and task specific documents are in place. All hot works will require a fire extinguisher at less than 20 meters on hand.

Hot work activities are to be strictly monitored by the Principal Contractor at all times.

d) Risk of fires caused by construction works and / or Smoking

Correct measures shall be in place for fire control to ensure no fires will break out. Fire extinguishing equipment to be readily available at all times especially during high-risk activities. The smoking of cigarettes is also to be monitored and adequate smoking areas and smoking control measures to be put in place.

The Principal Contractor is to implement, enforce and monitor fire safety and smoking safety discipline on site. For dry veld conditions, strict fire safety and prevention measures are to be adhered to.

The Principal Contractor is to ensure that sufficient firefighting resources are available as per the guidelines of competent service providers and industry best practices.

e) Existing services

All services (aboveground, ground level, underground etc.) must be protected by the contactor against damage or causing risk of injury during the works process. All necessary precautions must be taken to prevent accidental contact with these services. All services to be treated as live.
The Principal Contractor is to ensure that all applicable services, are detected, identified, and

protected before commencement of works.

f) Lifting Operations

All operators must provide copies of their up-to-date competency and medical certificates and driver's license. Loads must be slung by person with appropriate training and competence and flag persons as applicable. All lifting operations are to be conducted under the supervision of trained and competent lifting professionals.

Daily plant inspection registers to be completed and records kept in the Safety File. Valid Safe Working Load test certificates and record of inspections by competent personnel must be available and maintained throughout the project. Rotating amber lights and reverse alarms to be active when operating all plant on site. Plant must be effectively separated from members of public and unauthorised personnel. Exclusion zone under lifting operations to be enforced as applicable. Particular attention must be paid to lifting operations in windy conditions.

All lifting operations require a method Statement to be compiled and approved by the professional team.

All applicable regulations and SANS requirements related to lifting operations are to be adhered to by the contractor, especially in the case of tower crane lifted "Man Cages".

g) Noise and Dust control

The contractor is responsible for the management, monitoring and minimisation of dust and noise.

h) Use of hazardous substances

Must be in accordance with material safety data sheets and the relevant PPE must be available and worn. First aid measures to be in place.

i) Working at height and use of scaffolding

All access equipment to be built and maintained in a safe condition by competent and trained personnel. All scaffold structures must be built as per the SANS Regulations. This must be assessed by the contractor and Method Statements for these activities to be submitted for approval prior to work commencement.

A Fall Protection Plan and Rescue Plan is required for review by the Safety Agent prior to commencement of any activities at height. All workers must have Fall Protection Plan training in the form of a toolbox talk with a signed register of attendance.

Workers working at height must have appropriate and sufficient safety equipment. Safety harnesses with securely attached lanyards must be worn in areas where safety while working at height cannot be assured by other means. Edge protection in the form of guard rails and toe boards must be in place to prevent materials and people from falling. Medical certificates of fitness will be required for all contractors' staff, including those working at height.

All scaffolding is to be SANS 10085 compliant.

All scaffold erectors, supervisors and inspectors are to be trained and competent.

j) Temporary works, including scaffolding, formwork and support work

All temporary work must be designed by competent temporary works designers and constructed and inspected by competent personnel at the appropriate intervals as required by legislation and good practice and site circumstances. Results to be entered into a register on site.

All temporary works structures must be adequately erected, supported, braced and maintained by a competent person so that they are capable of supporting all anticipated vertical and lateral loads that may be applied to them. No loads to be imposed onto the structure that the structure is not designed to withstand. All required leading edge protection must be in place and storage of temporary works materials must be in a safe manner.

Exclusion zones and/or other measures to keep unauthorised personnel from accessing work areas underneath must be enforced.

k) Excavations and trenching

Method Statements to be in place. All workers must receive induction prior to commencement of works. Excavations must be sloped to a safe repose, or a stable box cut is to be used for shallow excavations if ground soil is stable in nature. If sloping or box cut is not possible, it must be adequately supported, braced and maintained by a competent person so that they are capable of supporting all anticipated vertical and lateral loads that may be applied to them. Support mechanisms to include shoring to prevent any excavation edges from collapsing.

Excavations must be backfilled by end of each shift as far as is reasonably practicable. If this cannot be done then appropriate safety measures must be put in place by the contractor to prevent unauthorised entry to excavations, including barriers at least 1.8m high and warning signage. Hard barriers with access control are to be used if excavated locations are to be left open when they are accessible to the general public. Ensure there is a safe distance between employees and plant when digging excavations.

The contractor is responsible for appointing a competent person that is suitably competent and

qualified regarding any shoring to be used/designed.
Excavated soil is to be placed at a sufficiently safe distance from the excavation itself.

All excavations must have a minimum of orange plastic barrier mesh in place or the equivalent plastic free (hessian/cloth) option when working in an ecological sensitive area.

Red and white barrier tape is not approved for use as a barrier to excavations.

Spoil heaps are to be secured from unauthorised access.

l) Electrical work

May only be undertaken after the requisite isolations and permits have been obtained and all required safety measures are in place. All required personal protective equipment must be worn. Live commissioning may only be undertaken by trained and competent contractor's personnel who are authorised and supervised by competent personnel. Lockout procedures to be implemented.

m) Moving Plant (construction & personnel transport)

All operators must provide copies of their competency and medical certificates and driver's license (including PDP's where applicable). Rotating amber lights and reverse alarms must be active when operating on site. Daily inspection registers to be completed and records kept in the Safety File. Trained flag persons to be used as applicable. Plant must be effectively separated from members of public and unauthorised personnel. Exclusion zones to be in operation as applicable. All vehicle operations on-site to comply with all the applicable OHS Act & Regulations.

Care must be taken with plant, equipment and construction vehicles when working near river, dam, channels, embankments, or other applicable water areas and ensure it does not fall into the river area or collapse embankments or water channels.

n) Delivery or support trucks on open roadways

Plant must be effectively separated from members of public and unauthorised personnel. Trained flag persons wearing high visibility clothing to be in place as required. Exclusion zone to be in operation when the support vehicles are in use next to the roadways.

Plant moving on roads and must always be made visible. Parking of this plant must always be strictly monitored.

o) Working over or next to water – risk of drowning.

It is essential that safe systems of work are in place based on a thorough risk assessment and that

staff are properly trained and instructed. To be addressed at induction where workers ability to swim to be recorded. Barriers to be placed on edge as required. Personal protective equipment (PPE) such as life vests and safety equipment such as life belts, ropes etc must be provided and readily available. Workers must not work alone near water and must know how to use the rescue equipment. An emergency rescue plan to be in place and must be communicated to all personnel. Consideration must also be given to the health implications of falls into the water.

p) Flooding

The Principle Contractor is to ensure that personnel are not placed in harm's way and shall monitor weather conditions where and when applicable. Pro-active steps regarding the safety of employees are to be taken when applicable.

Suitable monitoring practices regarding floods and the potential for the water to overwhelm newly worked on areas are to be implemented by the Principal Contractor.

q) Confined spaces

Confined space work must be monitored by a competent appointed person. Prior to entry, confined space to be sufficiently ventilated. Oxygen levels to be tested in confined space to ensure that it is safe for entry. Personal protective equipment to be worn (such as proper masks) if air supply insufficient or not of sufficient quality. Emergency procedures to be in place. Sufficient training must take place in use of equipment prior to any works commencing in such confined space. Permit system to be in place to declare confined space safe for entry.

r) Demolition

The Principal Contractor must appoint a competent person in writing to supervise and control all demolition work. The contractor must ensure that before any demolition work is carried out, and in order to ascertain the method of demolition to be used, a detailed structural engineering survey of the structure to be demolished is carried out by a competent person and that a method statement on the procedure to be followed is developed by that person. During demolition, the competent person must check the structural integrity of the structure at intervals determined in the method statement, in order to avoid any premature collapses.

s) Tree felling

Persons using chainsaws must be adequately trained and competent. PPE such as goggles, gloves, hard hat, ear defender and protective clothing to be worn. The chainsaw must be inspected and in good condition and a register to be kept. Exclusion zone to be enforced as appropriate.

t) Blasting

Injury to personnel and passers-by and damage to property by blast must be prevented. Blaster must have all relevant permits, permissions and licences in place before blasting. Permission from local authorities and police must be in place. A method statement must be approved prior to blasting. Members of public, residents and any other unauthorised persons to be decanted out of areas to be affected by blasting. Exclusion zone around perimeter of blasting and warning signage and barriers to be maintained. Blasting not to affect stability of adjacent structures/buildings.

Blasting done in areas with loose rocks or rock formations is to be formally managed. Unsecured, unplanned movement of rocks pose a significant risk during operations.

u) Hazardous and hot substances

Only trained operators to work with asphalt / bitumen. MSDS to be available. Principal Contractor must exercise caution as there is always a potential for fires. Suitable fire extinguisher to be in place at all times. Heated hazardous substances potentially produce fumes which can cause skin burns and eye injury and gastrointestinal and respiratory tract irritation. Gloves and suitable respiratory protection must be provided and worn as well as other appropriate personal protective equipment (PPE) as required by risk assessments. Bitumen not to be sprayed in adverse conditions.

v) Borrow Pits

All borrow pits shall be provided with suitable fences and shall be made safe so that people and livestock are not exposed to dangers. Health and safety in borrow pits are regulated by the Mine Health and Safety Act, 29 of 1996 and where this Act is silent on an aspect of health and safety, the requirements of the OH&S Act shall be applicable.

The borrow pit supervisors shall supervise all activities and work in the borrow pits according to the various regulations.

Borrow pits must be worked in such a manner that no water can accumulate.

w) COVID-19

The Principal Contractor is to review and implement measures for the safety management, hygiene and health procedures, protocols and practices, informing employees, monitoring and compliance with all Governmental Decrees regarding the management of the COVID-19 situation.

The Principal Contractor is to review at least the following, but not limited to, information.

- What is COVID-19?

- How does COVID-19 spread?
- What are the symptoms of COVID-19?
- When should testing for COVID-19 occur?
- How can COVID-19 infection be prevented?
- COVID-19 and stigma's or false information – What is true and what is false?

The below national and international information sources are recommended for review.

World Health Organization
https://www.who.int/emergencies/diseases/novel-coronavirus-2019

The Department of Health (Republic of South Africa)
http://www.health.gov.za/index.php/outbreaks/145-corona-virus-outbreak/465-corona-virus-outbreak

The National Institute for Communicable Diseases (Republic of South Africa)
http://www.nicd.ac.za/diseases-a-z-index/covid-19/frequently-asked-questions/

The Principal Contractor is recommended to be able to demonstrate/implement the below:

- Workplace safe work procedure and risk assessments;
- Hygiene protocols;
- Washing of hands – how, why and when;
- The use of hand sanitizers – how, why and when;
- Disinfecting of surfaces and workplace cleanliness – how, why and when;
- Social distancing within the workplace – how, why and when;
- Communication with employees;
- Employee and external contractor inductions;
- Awareness training;
- Safety signage in at least 3 languages – English, Afrikaans & Xhosa;
- Employee thermometer testing.
- Provision of PPE – gloves, masks, etc;
- Handwashing sessions;
- Employee health monitoring; and
- Strict COVID 19 control measures

x) Other construction hazards

Other hazards the contractor can reasonably expect are as follows:

- Asphalting
- Bricklaying
- Brush cutting

- Bulk mixing plant
- Compacting and filling
- Concrete pumping
- Crusher operation
- Cutting kerbs
- Cutting-off disc
- Electric tools and electrical installations
- Explosive actuated fastening devices
- Flammable liquids / gas
- Night work
- Hand tools
- Kerb laying
- Manhole rings and pipes storage
- Manual handling of general items
- Material / passenger hoist operation
- Mobile crane
- Painting
- Paving
- Plastering
- Plumbing
- Precast slab / unit laying and fixing
- Road construction
- Road marking
- Shuttering walls, beams, columns
- Site strip
- Skipping of concrete
- Steel erection
- Steel fixing
- Street lighting (high security masts)
- Tower crane erection and dismantling
- Tower scaffold
- Troxler use
- Working at height (excluding scaffold)

2.9.3 Excavation and Trenching (Construction Regulation 13)

The Excavations Method Statement shall include measures to ensure the safety of persons at all times. Particular care must be taken in areas where there is a high-water table.

The Engineer has the right to call in the services of a geotechnical engineer to make an assessment on the stability of any excavation should a dispute arise as to the safety of such excavation.

The contractor shall ensure that all excavation work is done in terms of the specifications and with due consideration of the Construction Regulations and are carried out under the supervision of the Excavation Supervisor or his assistants appointed as competent persons in terms of Regulation 13 (1) (a) and that all work is done in such a manner that no hazards are created by unsafe excavations and working conditions.

It is of particular importance that the design of any part of the excavation is adhered to. Where any deviation from the design is contemplated, permission by the designer.

2.9.4 Housekeeping, Stacking and Storage, and Placing Pipes (Construction Regulations 27 and 28)

The Stacking and Storage and Good Housekeeping Supervisor shall be appointed as responsible for good housekeeping and this person shall also be responsible for the handling and laying of pipelines. Proper procedures and handling methods shall be used during these activities to ensure the safety of Site staff and other persons.

2.9.5 Road and Rail Crossings

At roads and one railway lines, the danger of vehicle and train traffic will be encountered and the necessary procedures for safe accommodation of traffic and safety of Site staff, other persons and the public shall be followed.

The interests of the various road and rail authorities must also be protected, and their requirements complied with.

The Road and Rail Traffic Supervisor shall supervise and control these aspects of the Contract.

2.9.6 Service Crossings (Construction Regulation 24(a))

2.9.6.1 Underground Services

Proper procedures and handling methods as included in the Method Statements shall be used on encountering these services in order to protect construction personnel and other persons as well as the interests of the various Services authorities.

2.9.6.2 Overhead Services

The requirements of Electrical Machinery Regulations 19 (Clearance of power lines) and 21 (Crossings) that deal with power lines crossing roads (and the work Site), must be complied with at all times. Special attention must be given to construction vehicles and mobile plant and equipment that may travel under power lines with booms raised or extended or tip trucks with their bins raised. The attention of drivers and operators must be drawn to this hazard in their induction training and established procedures included for these operations in Method Statements.

2.9.7 Provision of Medical Services and First Aid (General Safety Regulation 3 and Client's Section 1 – General, Clause 1.8.3.12)

The Contractor shall provide a first aid post/sick bay and first aid stations at each working front. First Aid treatment shall be provided in terms of General Safety Regulation 3. First Aiders, foremen and work crew leaders shall be trained in, at least, basic first aid and possess a valid certificate to that effect issued by a Department of Labour approved first aid training provider. There shall be a person certified in first aid in each work crew.

Each first aider must have access to a first aid box, stocked as per General Safety Regulation 3 or carry a suitable pouch or container containing minimum requirements.

The Principal Contractor shall employ on Site the services of an occupational medical practitioner or make the necessary arrangements with such a practitioner to be available at all times whilst work is being performed on Site.

The Principal Contractor shall, likewise, ensure that adequate arrangements have been concluded for emergency medical aid e.g., ambulance, evacuation by air etc.

The Contractor shall put in place a monitoring system to monitor health risks throughout the life of the project.

2.9.8 Emergency and Rescue Procedures (Construction Regulation 29)

The Fire & Emergency Coordinator shall be responsible for emergency contingency planning and preparedness.

2.9.8.1 Evacuation and Rescue Procedures

No later than 28 days before the start of work in any area, including Site establishment, the Fire & Emergency Coordinator shall prepare and submit a Method Statement detailing evacuation and rescue procedures for the review of the Safety Agent.

The procedures shall detail the nature of the emergencies contemplated, the training of staff forming rescue teams, their numbers, availability (at least one team shall be available for each shift), any delegation of responsibility, liaison and back-up arrangements concluded with external emergency services and with the Safety Agent, the equipment needed, actual methods of evacuation including transport methods, medical facilities to be used, communications systems to be used and any other matter that the contractor considers relevant to the subject of emergency evacuation.

The emergencies contemplated shall include, at least, fire, flood, falls of ground, accidental leaks, spillages, explosion and serious injury.

The equipment requirements shall include those items needed to be used exclusively by the rescue

team/s, other equipment available that may be utilised and also the continuous operational readiness of plant and equipment, including standby facilities.

The procedures shall cover the level of medical competence of the rescue team/s, the use of support medical facilities and evacuation off Site to a medical facility, including the use of helicopter services or the access to air evacuation facilities.

All excavation operations shall be conducted with close reference and compliance to Construction Regulation 13 and the recommendations contained in the geotechnical report as issued. Where excavations will exceed 1m in depth, the Contractor will be required to submit a Method Statement and Risk Assessment to **the Client** and **Clients Safety Agent** for assessment prior to commencing with excavations, and **the Client/Client's Principal Agent** will issue a permit to proceed once the Risk Assessment and Method Statement are verified as suitable and sufficient.

- Every excavation must be provided with a safe means of access and egress that must be within 6 metres of any worker within the excavation and extend a minimum of 900mm above the ground;
- Warning signage to that effect is to be prominently displayed next to any excavations **within which or where persons are working or carrying out inspections or tests**. Where such excavations in which persons are working are in proximity to construction vehicle and mobile plant thoroughfares, demarcation shall be placed **at least 1.5 m** away from the edges of such excavation to ensure that no vehicle or plant moves near the edge of such excavation and may cause its collapse;
- The location and nature of any existing services such as water, electricity, gas etc. must be established before any excavation is commenced with, and any service that may be affected by the excavation must be protected and made safe before workers enter the excavation;
- The contractor shall ensure that no load, material, plant or equipment is placed or moved near the edge of any excavation where it may cause its collapse and endanger the safety of persons. Where excavations are in proximity to construction vehicle roadways, the contractor shall make provision for the erecting of barricading at a distance from the edge of the excavation that will ensure the stability of such excavations is not compromised, but not less than 1.5m from the edge;
- Taking into account soil conditions on the site as contained in the geotechnical report, all excavations deeper than 1.3 metres shall require dewatering during the rainy season and an upslope temporary berm will be required during construction to ensure surface runoff is diverted away from excavations to ensure safe working conditions;
- As far as is reasonably practicable, excavated material is to be placed at a distance equal to the depth of the excavation away from the edges of the excavation. Where this is not possible, the contractor is required to ensure sufficient shoring or bracing of such excavations;
- Every excavation including the shoring and bracing or any other method to prevent collapse must be inspected by the appointed competent person as follows:
  - **Daily before work commences** and before every shift;
  - After every blasting operation;

  - After an unexpected collapse of the excavation; and
  - After substantial damage to any supports or after rain, high winds or any other adverse weather condition.
- The results of all inspections must be recorded in a register kept on site;
- Upon entering any excavation deeper than 1.5m the precautionary measures contained in General Safety Regulation 5 – Work in confined spaces must be observed and complied with at all times;
- Procedures for co-ordination of construction related infrastructure on new projects and other projects under construction, as well as existing infrastructure must be implemented, safeguarding the integrity of existing and completed infrastructure, to ensure such infrastructure is not compromised by excavations; and
- No excavations may take place in proximity to completed structures, structures under construction and the base of tower cranes without the written approval of the Principal Agent, structural engineer and civil engineer. Such excavations may only be undertaken after the precautionary and protective measures required by the structural engineer to safeguard any structure or tower crane base have been installed, inspected and signed off by the Construction Manager. The Clients safety agent is to be provided with the structural engineer's report, contractors task specific method statement, risk assessment and safe work procedure for assessment prior to commencement of excavation in proximity to structures and tower crane bases.

2.9.8.2 Confined Space Procedures (General Safety Regulation 5)

Wherever practical, the contractor shall provide at any confined work area, alternative means of exit for use in the case of an emergency. Such emergency exits shall be clearly marked and shall be kept free from obstruction. All people employed in the work area shall be kept trained in the use of alternative exits by regular practice drills. In any confined area where it is not practical to provide an alternative means of exit, the Contractor shall provide adequate life support systems for the OH&S of people in the work area in the event of an emergency as contemplated above. The systems shall be capable of supporting life until rescue can be affected. They shall be maintained to a standard and kept at a level of readiness that satisfies the Safety Agent.

The contractor shall ensure that, in the case of a pipeline the relevant Method Statements provides for the monitoring, protection and rescue (when necessary) of workers inside the pipeline.

The contractor shall immediately implement and prominently advertise the procedures in each work area and shall test the effectiveness of the rescue procedures under the inspection of the Safety Agent at least every three months.

Work in confined spaces shall be deemed to be any work in an enclosed, restricted or limited space where a hazardous substance may accumulate or an oxygen deficient atmosphere may occur, including any chamber, tunnel, pipe, pit, sewer, container, deep excavation or similar construction in which a dangerous liquid or dangerous concentration of gas, vapour, dust or fumes may be present.

Excavations deeper than 1.5 metres, completed chambers and manholes will be classified as a confined space.

The contractor shall ensure that all the requirements of general safety regulation 5 are strictly complied with and that such confined space shall only be entered by an employee or any other person after the air therein has been tested and evaluated by a person competent to pronounce the safety thereof.

Equipment used for testing air quality or the presence of hazardous gasses, will be calibrated according to the manufacturer's instructions by a competent person/entity and valid calibration certificates available in the safety file.

The contractor shall develop a method statement, risk assessment and safe work procedure for work in confined spaces and such procedure shall outline the requirements of general safety regulation 5 as well as the safety requirements and rescue procedure for the retrieval of employees if required.

Should the task specific risk assessment indicate that manual evacuation of persons from a confined space will not be possible, the contractor is to provide a suitable mechanical rescue system and the rescue team is to be trained in the correct use of such rescue system in order to effect speedy and incident free rescues if required.

Where required, effective breathing apparatus shall be provided to any and all persons entering a confined space and the contractor shall keep available apparatus for resuscitation where work is conducted in confined spaces.

2.9.9 Electricity (Construction Regulation 24)

2.9.9.1 Responsibility for Electricity

The Electrical Installation Supervisor shall supervise the use and maintenance of electrical installations, electrical machinery, portable electrical tools and electrical appliances and shall ensure that such equipment complies with the Electrical Installation Regulations and the Electrical Machinery Regulations.

All temporary electrical installations on the Site shall also be under the control of the Electrical Installation Supervisor who shall inspect all temporary electrical installations on the Site at least once per week and electrical machinery by the user of the machinery daily before switched on.

2.9.9.2 Earthing Integrity

The integrity of the earthing of electrical extension leads and cables, portable electrical tools and electrical appliances shall be maintained at all times and any person found disconnecting or cutting earth wires or by-passing the earth in any way shall be subject to appropriate disciplinary action.

All power and lighting circuits are to be fitted with an earth leakage system. Such systems shall be tested at least monthly and any circuit where the earth leakage system is malfunctioning shall be repaired or replaced immediately.

2.9.9.3 Certificate of Compliance

A certificate of compliance shall be issued for every electrical installation on Site, whether permanent or temporary.

2.9.9.4 Lighting (Environmental Regulations for the Workplace 3)

The contractor shall ensure that lighting installed on the Site does not interfere with road (temporary or permanent) traffic control, safe passage of traffic or become a nuisance to the surrounding community.

Where poor or lack of illumination is identified as a hazard the requirements of the Environmental Regulations shall be complied with, and the following shall be included in the contractor's Method Statements:

- How lighting will be ensured/provided where daylight is not sufficient or at night;
- Planned maintenance programme for replacing luminaries; and
- Proof of illumination levels of artificial illumination provided.

2.9.10 Transport

2.9.10.1 Personnel and Road Safety

The Construction vehicle and Mobile Plant Supervisor shall supervise and control all aspects of the safe transport of personnel, machinery, materials, goods and other loads.

The contractor shall make provision for the safe vehicular transport of all personnel and shall prohibit his personnel from riding as passengers on excavation plant, dumpers or any other mobile plant that does not have provision for the safe transport of persons. Flatbed trucks or similar vehicles may only be used for transport of labour if fitted with acceptable side restraints and adequate seating.

Weatherproof covering to personnel transport shall be fitted to the vehicle at all times. The prevention of overloading of vehicles shall be rigidly enforced by the Construction vehicle and Mobile Plant Supervisor. Crush barriers of adequate standard shall be provided at all personnel loading points.

It shall be the responsibility of the driver of a vehicle to ensure that the passengers are in a safe position and the load properly secured before moving off in his/her vehicle.

If persons are conveyed together with a load, the load must be positioned and secured so that it cannot move and strike or crush the persons on the vehicle even in the event of severe braking or collision. The Principal Contractor shall include in his Method Statement the means by which these

requirements will be met at all times.

The principles of road safety both on and off the Site shall be adhered to.

The Principal Contractor shall require all suppliers to ensure that all materials are appropriately secured to ensure safe passage to and from Site. Special care shall be taken by plant, delivery vehicles and haulage trucks entering and leaving the Site.

2.9.10.2 Construction Vehicles and Mobile Plant (CV&MP) (Construction Regulation 23)

The Construction vehicle and mobile Plant Supervisor shall supervise the use and maintenance of CV&MP.

The contractor shall provide all drivers and operators of CV&MP with proof of authority to operate which proof must be producible by the driver or operator together with a current driver's licence of the correct category (where applicable) whilst driving or operating the equipment for which he/she has been authorised.

Drivers and operators of CV&MP shall conduct an inspection of their machine/vehicle every day before start-up and the record of this inspection must be available on the machine whilst it is being used.

The contractor shall ensure the following with respect to the CV&MP:

a) All CV&MP shall be maintained in good working order in order to maximise efficiency and minimise pollution;
b) All CV&MP shall be equipped with an audible reversing warning system;
c) All drivers and operators shall be appointed as such and be tested for competence before employment on the Site. Their competence shall also be tested at yearly intervals during the Contract. The pre-employment and yearly competence tests of drivers shall in addition to testing their driving ability, also test their eyesight, including night vision and colour perception;
d) All CV&MP shall be equipped with a 4.5 kg minimum weight dry powder fire extinguisher;
e) All vehicles shall carry an up-to-date roadworthy certificate and have a current license;
f) All CV&MP shall be repaired, maintained and serviced in an official workshop and not on Site except for emergency repairs for removal to a workshop or for top-up of oil, fuel and water;
g) All CV&MP shall only be washed in designated washing areas to minimise water pollution and soil contamination; and
h) Contractors' and hired-in/rented CV&MP will be regarded as being that of the contractor and shall comply with the same requirements and standards as applies to the Contractor's CV&MP.

Also refer to other requirements of the Construction Regulation 23.

2.9.11 Traffic Accommodation

The Road supervisor shall be responsible for the safe control of traffic on construction and public roads. Access control to prevent access of the public to the construction areas shall be maintained.

The requirements of the Road Traffic Act (Act 93 of 1996) as well as the requirements of relevant authorities shall be complied with at all times with particular attention to signage and flagmen.

The Contractor shall develop and implement a site-specific traffic management plan and procedure, accompanied by a schematic site plan to comply to the requirements of CR23(1)(f) and CR23(2)(b). Such traffic management plan is to include the procedure and signalling arrangements for Stop/Go, construction vehicles and mobile plant accessing into and egressing from the site onto public and gravel access roadways, as well as the management and control of movement of construction vehicles and mobile plant on the site.

In addition to the above, the traffic management plan shall include the procedure and arrangements for safeguarding the public from stationary construction vehicles on public roads, including mobile plant and supplier's vehicles.

A suitable number of signallers (traffic controllers) are to be appointed to ensure compliance to the traffic management plan and shall be adequately trained to ensure the safety of the public and construction personnel. Proof of such training is to be available in the site safety file. Road traffic signs to be placed warning other road users of construction work and construction vehicles travelling in proximity. Road traffic signages to be checked, cleaned and maintained daily with evidence recorded on a register placed in the site file. Amber warning lights to be fixed to signages to ensure farmers and other access road users can see construction signages at night.

Traffic controllers to be positioned on either side of any access/egress areas of site to control oncoming traffic **from both directions** and issued with red flags for signalling. When visibility is poor, flags to be replaced with luminous batons.

2.9.12 Safety of the Public (Section 9 of the OH&S Act)

The Contractor shall ensure that the public affected by the construction work are made aware of the dangers of the construction work and of the precautionary measures to comply with in order to avoid or minimise those dangers.

Appropriate signage, flagmen, barriers and warning signs, shall be in place and all employees on Site shall be instructed in ways of ensuring that the public is protected at all times.

All non-employees and visitors entering the Site on business shall be required to report to the Site office and shall receive induction on the hazards and risks on Site and the measures in place for avoiding these.

Referencing OHS Act Section 9, all Contractors will be responsible for ensuring that all non-employees, consulting team members and their visitors, all visitors and all **Client** employees who wish to gain entry onto site in addition to all non-employees working on this project and are affected by the construction work are made aware of the dangers likely to arise from said construction work as well as the precautionary measures to be observed to avoid or minimise those dangers.

Examples of non-employees are: Non-employees entering the site for whatever reason, the surrounding community, passers-by to the site (pedestrians and road users) and the general public.

Appropriate signage warning of construction related hazards must be posted in prominent positions in and around the construction site and all employees on site must be instructed to ensure that non-employees are protected at all times.

The construction site area shall be fenced as a minimum with a diamond mesh fence of at least 1.8 meters in height and covered with shade netting. The contractor will ensure that all access to the construction area is controlled and enforced.

All non-employees on **entering** the site must receive induction on the hazards and risks and the control measures to mitigate these and shall be accompanied to the site office by a person designated thereto.

Adequate dust suppression measures must be implemented to minimise the exposure of the surrounding community and general public to excessive levels of airborne dust.

All truck loads must be covered or adequately secured to prevent the fall of material onto public roads.

The traffic management plan is to be implemented and maintained in respect of ensuring the health and safety of public road users and pedestrians associated with the access and egress of site by construction vehicles and mobile plant.

Noise levels are to be managed during construction to minimise disturbance to neighbouring properties and the general public in proximity to the construction site.

2.9.13 The Use of Explosives

The Contractor shall comply with the relevant explosives legislation.

In addition to his compliance with the Explosives Regulations (Regulation R109), the Contractor shall submit to the Engineer for his review, full and detailed Method Statements, prepared in terms of the requirements of the Explosives Regulations and the Contract requirements, for the use of explosives on the construction of the Works.

The Method Statements shall at least include details of:

a) The locations of blasting works;
b) The location and size of storage magazine(s), the explosives register, details of security fencing, earthing of magazine building(s);
c) Danger signs that shall be prominently displayed at all areas where explosives are stored or used;
d) Transportation of explosives;
e) Licences obtained for the magazine(s);
f) The temporary storage at the place of use;
g) The use of explosives and dealing with misfires;
h) The types of explosive and detonators contemplated;
i) The method for ensuring that all excavation spoil is free of undetonated caps, explosive residues and the safe disposal thereof;
j) Fencing off excavations and spoil dumps and preventing unauthorised entry; and
k) The names, qualifications and experience of those people responsible for the handling and use of explosives. In addition to the blasting licence referred to in the Explosives Regulations, the personnel who shall be responsible for supervising the charging of drill holes with explosives and the blasting shall have documentary proof that they have at least five years' experience in supervising the loading and firing of charges in similar works.

Notwithstanding the provisions of the Explosives Regulations, any person who is licensed in the storage, handling and in the use of explosives must be literate, of good sight and hearing and well experienced in the work he is to carry out.

Notwithstanding the provisions of the Explosives Regulations, the Contractor shall:

a) Keep on Site valid certified copies of licences. All licence holders shall carry valid certified copies when performing blasting work; and
b) Install and operate at each point where a blast is to take place an electrically operated siren of sufficient volume to be easily heard under all circumstances within a 1 km radius of any blast. Hand operated sirens may only be used in areas of restricted access such as a tunnel heading where access is fully controlled. Sirens shall be sounded for at least 5 minutes before any blast takes place and shall continue for one minute after the blast has taken place. In addition to the above, the Contractor shall station men on roads and elsewhere with red flags to prevent persons, animals and traffic entering or remaining within the danger zone.

Care shall be taken to ensure that all possible approach routes to the danger zone are covered by these warning arrangements. Blasting shall not be carried out unless occupants of any nearby buildings or working areas have been notified by the Contractor at least 24 hours in advance. After blasting, no person shall approach the area until it has been examined by the Explosives Supervisor and declared safe.

The Contractor shall provide for the review of the Engineer details of each and every blasting operation at least 24 hours before that operation is to be carried out. The details shall show the location of and the intended time of each blast, the number, size and length of each blast hole, the quantity and types of explosives and detonators to be used and the name of the licensed blaster and Explosives Supervisor responsible.

2.9.14 Heavy Rain, Lightning and Flooding (Environmental Regulations for Workplaces 8)

The Contractor shall take adequate precautions against lightning.

No charging or blasting shall take place if the imminent approach of lightning to the Site is forecast. All charged areas shall be immediately evacuated.

Where there is a likelihood of flooding of the workplace, measures for the timeous warning of flooding must be put in place. A critical consideration in this regard is the protection of workers in the pipeline in the event of a flood, and the Contractor's Method Statement shall clearly indicate his intended means of addressing this eventuality.

2.9.15 Personal Protective and Safety Equipment (General Safety Regulation 2)

The Contractor's Risk Assessment shall include the requirements of personal protective and safety equipment, to be provided to all persons on the Site.

The Contractor shall ensure that all persons on Site are made aware of the need and trained to use the prescribed equipment, and this shall be monitored and enforced by Site managers, foremen and supervisors and corrective measured shall be applied in the event of non-compliance.

All workers shall be supplied with the required Personal Protective Equipment (PPE) as per the Occupational Health and Safety Act, 2014. All construction personnel must be clearly identifiable and must be issued with employee cards for identification purposes.

2.9.16 Eating, Changing, Washing and Toilet Facilities (Construction Regulation 30)

The following minimum requirements shall be provided by the Contractor:

2.9.16.1 Toilets

At or within 100 m of each workplace, adequate toilet facilities shall be provided with toilet paper, potable water, soap and means of washing and drying hands together with barrier creams where necessary. These facilities shall be maintained in a clean and sanitary condition at all times.

Where used at the construction fronts, chemical toilets shall be maintained according to the supplier's instructions.

At least one sanitary facility for each sex and for every 30 workers is required.

2.9.16.2 Showers

At least one shower facility with hot and cold water for every 15 persons of each sex is required.

2.9.16.3 Change Rooms

Changing facilities must be provided separately for each sex.

2.9.16.4 Eating Facilities

Eating facilities shall be sheltered from the sun, wind and rain.

The preparation and serving of food or beverage shall be carried out under controlled and hygienic conditions of high standard.

Designated eating areas shall be provided and clearly demarcated, and noise in these areas shall be limited.

Sufficient rubbish bins are to be provided at all eating areas.

2.9.17 Hazardous Substances

The Principal Contractor shall identify and keep records of all hazardous materials, or other substances to be used during the Contract.

2.9.17.1 Hazardous Chemical Substances (HCS) (Hazardous Chemical Agent Regulations 2021)

The Contractor shall:

a) Appoint the Stacking and Storage Supervisor to control the use and storage of HCS;
b) Include in his Method Statement details of the substances/materials to be used together with the storage, handling and disposal procedures of the materials;
c) Ensure that Material Safety Data Sheets (MSDS) are available on Site for every hazardous substance. Procedures detailed in the MSDS shall be followed whilst storing or using HCS and in the event of an emergency situation; and
d) Ensure that the procurement, transportation, storage, handling, use and disposal of hazardous substances complies with the Environmental Conservation Act (1989), National Environmental Management Act and the Hazardous Chemical Substances Regulations, and the manufacturer’s instructions.

2.9.17.2 Flammable Liquids (Construction Regulation 25)

The Stacking and Storage Supervisor shall supervise the use and storage of flammables.

The Contractor shall comply with the provisions of General Safety Regulation 4 and all the provisions of Construction Regulation 25 to ensure a safe and hazard-free environment to all workers and other persons on Site. These requirements include:

a) No person is required or permitted to work in a place where there is the danger of fire or an explosion due to flammable vapours being present unless adequate precautions are taken;
b) No flammable is used or applied unless there is no danger of fire or explosion due to the application of adequate ventilation;
c) The workplace is effectively ventilated. Where this cannot be achieved employees must wear suitable respiratory equipment;
d) No smoking or other sources of ignition is allowed in the area where flammable vapours may be present;
e) Flammable areas are conspicuously demarcated as “flammable”;
f) Flammables stored on a construction Site are stored in a well-ventilated, reasonably fire-resistant container, cage or room that is kept locked with access control measures in place and sufficient firefighting equipment installed and fire prevention methods practised;
g) Flammables are stored in a permanent flammables store so that no fire or explosion is caused i.e.;
    i) Stored in a locked, well-ventilated reasonably fire-resistant container, cage or room;
    ii) Conspicuously demarcated as “Flammable Store – No Smoking or Naked Lights”;
    iii) The flammables store to be constructed of two-hour fire-retardant walls and roof and separated from adjoining rooms or workplaces by means of a two-hour fire-retardant fire wall;
    iv) Adequate and suitable firefighting equipment are installed around the flammables store and marked with the prescribed signs;
    v) All electrical switches and fittings to be of a flameproof design;
    vi) Any work done with tools in a flammables store or work areas to be of a non-sparking nature;
    vii) No Class A combustibles such as paper, cardboard, wood, plastic, straw etc. to be stored together with flammables;
    viii) The flammable store to be designed and constructed to, in the event of spillage of liquids in the store, to contain the full quantity + 10% of the liquids stored; and
    ix) A sign indicating the capacity of the store to be displayed on the door.
h) Only one day’s quantity of flammables is to be kept in the workplace;
i) Containers (including empty containers) to be kept closed to prevent fumes/vapours from escaping and accumulating in low lying areas;
j) Metal containers to be bonded to earth whilst decanting to prevent build-up of static; and
k) Welding and other flammable gases to be stored segregated as to type of gas and empty and full cylinders.

2.9.17.3 Fuel (Petrol and Diesel) and Oil

The Contractor shall:

- Demarcate fuel storage areas and provide at these areas adequate security, control, fire and

hazard signage;

- Ensure that plant be refuelled at designated re-fuelling areas only;
- Ensure that a spillage kit is available at all fuel storage and re-fuelling areas. The kit should be able to handle a full storage spill;
- Ensure that storage tanks and re-fuelling tanks are placed on an impermeable surface and within an impermeable bunded area; and
- Ensure that re-fuelling points are sloped to a collection pit.

All storage, re-fuelling and spillage containment areas, containers of hazardous substances and dangerous equipment shall be clearly and prominently marked as such, in English and in the local language, as well as any other relevant languages used by the workforce.

The Contractor shall conduct and document, at least weekly, inspections of the storage areas for equipment, transport vehicles and hazardous materials and substances, looking especially for spillages and leaks. In accordance with Section 8 - Dealing with Water, a Method Statement shall demonstrate how spills of toxic or unacceptable contaminants will be prevented from entering storm water systems and water courses, and also indicate how areas outside the Site will be cleared to protect the environment and maintain the safety of people.

The Method Statement shall include plans and drawings of proposed dedicated buildings or proposed protected containment areas that will be used to contain or store hazardous substances. The Method Statement shall include methods of ventilation and of containing spillage and shall indicate the method of clearing any spillage which may occur.

2.9.17.4 Hazardous Biological Agents (HBA) (HBA Regulations)

The Baseline Risk Assessment contemplated in Clause 2.4 shall address exposure of persons to Hazardous Biological Agents and include an issue-based Risk Assessment for this eventuality that must include:

a) Nature and dose of HBA;
b) Where HBA may be present and in what physical form;
c) The nature of work or process;
d) Steps in the event of failure of control measures;
e) The effect of the HBA;
f) The period of exposure;
g) Control measures to be implemented and how exposure to HBA is to be controlled;
h) The provision of personal protective equipment; and
i) What information and training are to be provided to employees regarding the following:
    - The contents of these regulations;
    - Potential risks to health;
    - Control measures to be implemented; and
    - The correct use and maintenance of personal protective equipment.

Medical surveillance shall be conducted in terms of the requirements of the HBA Regulations.

Monitoring shall continue during the period of the Contract and a further surveillance conducted after completion of the Contract.

2.9.18 Welding (General Safety Regulation 9)

The Principal Contractor's Risk Assessment and Method Statement shall include welding operations.

2.9.19 Ventilation and Working in Confined Spaces (Environmental Regulations for Workplaces 5 and General Safety Regulation 5)

Particular attention shall be paid to the requirements of General Safety Regulation 5: "Working in Confined Spaces" and Environmental Regulation for Workplaces 5: "Ventilation".

The Contractor's Risk Assessment and Method Statement shall include details of the training of workers to work in confined spaces, the measures contemplated in the event of an emergency and the provision of adequate ventilation at all times.

In terms of General Safety Regulation 5(1) the atmosphere in the pipelines and all other confined spaces shall be tested daily by a confined space competent person to ensure that the air is safe to breath. The results of the test/s shall be entered into a register and workers may only enter after the aforementioned competent person has made a written entry in the register that it is safe to do so.

Forced ventilation shall be applied where the air is not suitable for breathing and if this is not possible, suitable respirators shall be worn.

Forced ventilation shall be applied where the WBGT index exceeds 30 in the pipeline. If this is not possible, work activities shall be curtailed until the index is below 30 (Environmental Regulation for Workplaces 2(4)).

2.9.20 Sources of Radiation (Nuclear Density Gauge -Troxler)

The use of a Troxler on site must be in line with the SANS 3001 of March 2014.

This method forms part of a set of methods used to operate nuclear gauges, and includes the following:

a) Administration, handling, and maintenance (see SANS 3001-NG1);
b) Validation of standard calibration blocks (see SANS 3001-NG2);
c) Calibration of a nuclear gauge (see SANS 3001-NG3);
d) Verification of a nuclear gauge (see SANS 3001-NG4):
e) In situ density determination using a nuclear gauge (see SANS 3001-NG5)

Troxlers must:

- Be stored in a dedicated, lockable area and must have a warning signage displayed;

- Only transported in a dedicated vehicle with the required signage displayed and by an authorised employee that has been appointed in writing;
- Have a Troxler Calibration Certificate in place.
- Have a Troxler Technician Appointment on file and signed and proof of competency within the safety file.

The Contractor's Risk Assessment and Method Statement shall address the use of Radioactive sources.

2.9.21 Temporary Works (Formwork and Support Work) (Construction Regulation 12)

A contractor must appoint a temporary works designer in writing to design, inspect and approve the erected temporary works on site before use.

A contractor must ensure that all temporary works operations are carried out under the supervision of a competent person who has been appointed in writing for that purpose.

A contractor must ensure that:

- All temporary works structures are adequately erected, supported, braced and maintained by a competent person so that they are capable of supporting all anticipated vertical and lateral loads that may be applied to them, and that no loads are imposed onto the structure that the structure is not designed to withstand;
- All temporary works structures are done with close reference to the structural design drawings, and where any uncertainty exists the structural designer should be consulted;
- Detailed activity specific drawings pertaining to the design of temporary works structures are kept on the site and are available on request to an inspector, other contractors, the Client, the Client's Safety Agent, or any employee;
- All persons required to erect, move, or dismantle temporary works structures are provided with adequate training and instruction to perform those operations safely;
- All equipment used in temporary works structures are carefully examined and checked for suitability by a competent person, before being used;
- All temporary works structures are inspected by a competent person immediately before, during and after the placement of concrete, after inclement weather or any other imposed load and at least on a daily basis until the temporary works structure has been removed and the results have been recorded in a register and made available on site;
- No person may cast concrete, until authorization in writing has been given by the competent person contemplated above;
- If, after erection, any temporary works structure is found to be damaged or weakened to such a degree that its integrity is affected, it is safely removed or reinforced immediately;
- Adequate precautionary measures are taken in order to:
    - secure any deck panels against displacement; and

- prevent any person from slipping on temporary works due to the application of release agents;

- As far as is reasonably practicable, the health of any person is not affected through the use of solvents or oils or any other similar substances;
- Upon casting concrete, the temporary works structure is left in place until the concrete has acquired sufficient strength to safely support its own weight and any imposed load, and is not removed until authorization in writing has been given by the competent person;
- The foundation conditions are suitable to withstand the loads caused by the temporary works structure and any imposed load in accordance with the temporary works design;
- Provision is made for safe access by means of secured ladders or staircases for all work to be carried out above the foundation bearing level;
- A temporary works drawing, or any other relevant document includes construction sequences and methods statements;
- The temporary works designer has been issued with the latest revision of any relevant structural design drawing;
- A temporary works design and drawing is used only for its intended purpose and for a specific portion of a construction site; and
- The temporary works drawings are approved by the temporary works designer before the erection of any temporary works.

No contractor may use a temporary works design and drawing for any work other than its intended purpose.

2.9.22 Scaffolding (Construction Regulation 16)

A contractor must appoint a competent person in writing who must ensure that all scaffolding work operations are carried out under his or her supervision and that all scaffold erectors, team leaders and inspectors are competent to carry out their work as per the SANS 10085 of 2004.

A contractor using access scaffolding must ensure that such scaffolding, when in use, complies with the safety standards incorporated for this purpose into these Regulations under section 44 of the Act and SANS 10085.

Scaffolding must comply with the following:

- Access Scaffolding must be erected, used and maintained safely in accordance with Construction Regulation 16 and SA Bureau of Standards Code of Practice, SANS 10085-1 entitled, "The Design, Erection, and Use & Inspection of Access Scaffolding";
- Detailed consideration must be given to all scaffolding to ensure that it is properly planned to meet the working requirements, designed to carry the necessary loadings and maintained in a sound condition. It must also be ensured that there is sufficient material available to erect the scaffolding properly;

- Scaffolding may only be erected, altered or dismantled by a person who has the appropriate training and experience in this type of work and under the supervision of such a person, who has been appointed in writing;
- Specific attention must be given to the appointment of Scaffolding Inspectors and Scaffolding Erectors who shall not be the same person. The continuous inspection of each scaffolding structure must be recorded and kept up to date on an applicable scaffold inspection register. Each scaffold structure is to have a unique identification number/location and separate inspection register;
- Tags/Signs reflecting the current status of the scaffold must be used and fixed to the structure **at all times**. These tags will reflect either 'Safe to use' or 'Scaffold not Safe' on **both sides** of the tag/sign, to avoid confusion regarding the status of the scaffolding structure. Scaffolding with no tags attached will be deemed to be non-compliant;
- Where scaffolding spans multiple storeys of the structure, status tags must be prominently displayed **on each floor** wherever it may be possible to access the scaffolding;
- Where scaffolding is erected adjacent to pavements and public walkways, the scaffolding structure is to have shade netting installed and adequately secured to prevent the fall of tools, equipment and material into walkways, and public areas and persons being struck by falling objects;
- On completion of the erection of scaffolding, the appointed scaffold inspector will inspect the structure and will ensure it is in sound working order and complies with all statutory regulations. In the event that the scaffolding is erected by a supplier, the supplier will then issue a handover certificate to the Contractor as the user of the scaffolding. Drawings, design and specifications shall be signed by an engineer; and
- The completed scaffold shall also be inspected by the Construction Manager for approval prior to use. Should any additional load i.e. a hoist or advertising banners be added to the scaffold at a later stage, the professional engineer must approve the modification.

2.9.23 Demolition Work (Construction Regulation 14)

A contractor must appoint a competent person in writing to supervise and control all demolition work on site.

A contractor must ensure that before any demolition work is carried out, and in order to ascertain the method of demolition to be used, a detailed structural engineering survey of the structure to be demolished is carried out by a competent person and that a method statement on the procedure to be followed in demolishing the structure is developed by that person.

During a demolition, the competent person contemplated in above must check the structural integrity of the structure at intervals determined in the method statement contemplated in above, in order to avoid any premature collapses.

A contractor who performs demolition work must, with regard to a structure being demolished, take steps to ensure that;

- No floor, roof or other part of the structure is overloaded with debris or material in a manner which would render it unsafe;
- All reasonably practicable precautions are taken to avoid the danger of the structure collapsing when any part of the framing of a framed or partly framed building is removed, or when reinforced concrete is cut;
- Precautions are taken in the form of adequate shoring or other means that may be necessary to prevent the accidental collapse of any part of the structure or adjoining structure;
- No person works under overhanging material or a structure which has not been adequately supported, shored, or braced;
- Any support, shoring, or bracing contemplated above, is designed and constructed so that it is strong enough to support the overhanging material;
- Where the stability of an adjoining building, structure or road is likely to be affected by demolition work on a structure, steps are taken to ensure the stability of such structure or road and the safety of persons;
- As far as is reasonably practicable, ascertain the location and nature of electricity, water, gas or other similar services which may in any way be affected by the work to be performed, and before the commencement of demolition work that may affect any such service, steps that are necessary to render circumstances safe for all persons involved are taken;
- Every stairwell used and every floor where work is being performed in a building being demolished, be adequately illuminated by either natural or artificial means;
- Convenient and safe means of access be provided to every part of the demolition site in which persons are required to work;
- A catch platform or net is erected above an entrance or passageway or above a place where persons work or pass under or fence off the danger areas if work is being performed above such entrance, passageway, or place so as to ensure that all persons are kept safe where there is a danger or possibility of persons being struck by falling objects; and
- No material is dropped to any point, which falls outside the exterior walls of the structure, unless the area is effectively protected.

No person may dispose of waste and debris from a high place by a chute unless the chute:

- Is adequately constructed and rigidly fastened;
- If inclined at an angle of more than 45 degrees to the horizontal, is enclosed on its four sides;
- If of the open type, is inclined at an angle of less than 45 degrees to the horizontal;
- Where necessary, is fitted with a gate at the bottom end to control the flow of material; and discharges into a container or an enclosed area surrounded by barriers.

Every chute used to dispose of rubble must be designed in such a manner that rubble does not free-fall and that the chute is strong enough to withstand the force of the debris travelling along the chute.

No equipment shall be used on floors or working surfaces unless such floors or surfaces are of sufficient strength to support the imposed loads.

Where a risk assessment indicates the presence of asbestos, a contractor must ensure that all asbestos related work is conducted in accordance with the Asbestos Abatement Regulations, 2020.

Where a risk assessment indicates the presence of lead, a contractor must ensure that all lead related work is conducted in accordance with the Lead Regulations, 2001.

Where the demolition work involves the use of explosives, a method statement must be developed in accordance with the applicable explosives legislation, by an appointed person who is competent in the use of explosives for demolition work and all persons involved in the demolition works must adhere to demolition procedures issued by the appointed person.

A contractor must ensure that all waste and debris are, as soon as reasonably practicable, removed and disposed of from the site in accordance with the applicable legislation.

2.9.24 Tunnelling and Pipe Jacking (Construction Regulation 15 & 23)

The Tunnelling and Pipe Jacking Supervisor shall supervise any tunnelling and pipe jacking.

No person may enter a tunnel which has a height dimension of less than 800 mm.

The Contractor’s Method Statement shall address any tunnelling and pipe jacking operations.

2.9.25 Bulk Mixing Plants (Construction Regulation 20)

A contractor must ensure that the operation of a bulk mixing plant is supervised by a competent person who has been appointed in writing and is:

- Aware of all the dangers involved in the operation thereof; and
- Conversant with the precautionary measures to be taken in the interest of health and safety.

No person supervising or operating a bulk mixing plant may authorize any other person to operate the plant unless that person is competent to operate a bulk mixing plant.

A contractor must ensure that the placement and erection of a bulk mixing plant complies with the requirements set out by the manufacturer and that such plant is erected as designed.

A contractor must ensure that all devices to start and stop a bulk mixing plant are provided and that those devices are placed in an easily accessible position and constructed in a manner to prevent accidental starting.

A contractor must ensure that the machinery and plant selected is suitable for the mixing task and that all dangerous moving parts of a mixer are placed beyond the reach of persons by means of doors, covers or other similar means.

No person may remove or modify any guard or safety equipment relating to a bulk mixing plant, unless authorized to do so by the appointed person.

A contractor must ensure that all precautionary measures stipulated for confined spaces as determined in the General Safety Regulations, 2003, are complied with when entering any silo.

A contractor must ensure that a record is kept of all repairs or maintenance to a bulk mixing plant and that the record is available on site to an inspector, the Client, the Client's Safety Agent, or any employee.

2.9.26 Lifting Machines and Equipment (Construction Regulation 22 and Driven Machinery regulation 18)

The Lifting Machines and Equipment Supervisor shall supervise the use and maintenance of lifting machines and equipment, including cranes and tower cranes.

The Contractor shall use and maintain lifting machines and equipment in accordance with the requirements of Driven Machinery Regulation 18 and Construction Regulation 22.

The Contractor shall ensure that lifting machinery and tackle is inspected before use and at least on a monthly basis. The Contractor shall have a lifting machinery and tackle inspector who will inspect the equipment at intervals required by the Driven Machinery Regulations, taking into account that:

- All lifting machinery and tackle have a safe working load clearly indicated;
- Regular inspection and servicing is carried out;
- Records are kept of inspections and of service certificates;
- Thorough examinations are carried out by competent personnel at the frequencies required by legislation;
- There is proper supervision in terms of guiding the loads which includes a trained banks man to direct and check lifting tackle if it is safe for use;
- Forklift to be inspected at least every year and lift plan at least every 2 years
- Load test certificate to be not older than 6 months;
- Sufficient props to be used and max weight to be displayed;
- Slings to be checked with regard to integrity, chains, serial numbers, checked for tears, cuts links and all other materials;
- Hooks to be oiled, not in a fixed position and closed to prevent materials from slipping/falling off; and
- Lifting equipment must be used for the scope of work carried out.

2.9.27 Housekeeping on Construction Sites (Construction Regulation 27)

A contractor must, in addition to compliance with the Environmental Regulations for Workplaces, 1987, promulgated by Government Notice No. R. 2281 of 16 October 1987, ensure that suitable housekeeping is continuously implemented on each construction site, including-

- The proper storage of materials and equipment;
- The removal of scrap, waste and debris at appropriate intervals;
- Ensuring that materials required for use, are not placed on the site so as to obstruct means of access to and egress from workplaces and passageways;
- Ensuring that materials which are no longer required for use, do not accumulate on and are removed from the site at appropriate intervals;
- Ensuring that waste and debris are not disposed of from a high place with a chute, unless the chute complies with the requirements set out in the regulations;
- Ensuring that construction sites in built-up areas adjacent to a public way are suitably and sufficiently fenced off and provided with controlled access points to prevent the entry of unauthorized persons; and
- Ensuring that a catch platform or net is erected above an entrance or passageway or above a place where persons work or pass under or fencing off the danger area if work is being performed above such entrance, passageway, or place so as to ensure that all persons are kept safe in the case of danger or possibility of persons being struck by falling objects.

The Stacking and Storage Supervisor shall be responsible for good housekeeping.

Applicable notice boards and hazard warning notices shall be put in place and secured. Night hazards to be indicated suitably (e.g., reflectors, lighting and traffic signage).
Emergency contact details to be prominently displayed.

2.9.28 Fire Precautions on Construction Sites (Construction Regulation 29)

A contractor must, in addition to compliance with the Environmental Regulations for Workplaces, 2003, ensure that –

- All appropriate measures are taken to avoid the risk of fire;
- Sufficient and suitable storage is provided for flammable liquids, solids, and gases;
- Smoking is prohibited and notices in this regard are prominently displayed in all places containing readily combustible or flammable materials;
- In confined spaces and other places in which flammable gases, vapours or dust can cause danger:
    - only suitably protected electrical installations and equipment, including portable lights, are used;
    - there are no flames or similar means of ignition;
    - there are conspicuous notices prohibiting smoking;
    - oily rags, waste, and other substances liable to ignite are without delay removed to a safe place; and

  - adequate ventilation is provided;
- Combustible materials do not accumulate on the construction site;
- Welding, flame cutting, and other hot work are done only after appropriate precautions have been taken to reduce the risk of fire;
- Suitable and sufficient fire-extinguishing equipment is placed at strategic locations or as may be recommended by the Fire Chief or local authority concerned, and that such equipment is maintained in a good working order;
- The fire equipment contemplated above is inspected by a competent person, who has been appointed in writing for that purpose, in the manner indicated by the manufacturer thereof;
- A sufficient number of workers are trained in the use of fire-extinguishing equipment;
- Where appropriate, suitable visual signs are provided to clearly indicate the escape routes in the case of a fire;
- The means of escape is kept clear at all times;
- There is an effective evacuation plan providing for all:
  - persons to be evacuated speedily without panic;
  - persons to be accounted for; and
  - plant and processes to be shut down; and
- A siren is installed and sounded in the event of a fire.

The Emergency, Security and Fire Coordinator shall be responsible for fire prevention. This aspect shall be addressed in the Emergency Contingency Plan included in the Contractor's Method Statement.

2.9.29 Water Environments (Construction Regulation 26)

The Working on or near Water Supervisor shall supervise work on or over water and where persons are at risk of falling into any body of deep water. The Contractor's Method Statement shall address these aspects.

Where construction work is done over or in close proximity to water, the Contractor shall ensure that measures are in place:

- To prevent workers from falling into the water and drowning. These measure to include railings and the availability of lifejackets;
- To rescue any worker/s that has fallen into the water; and
- For the timeous warning of flooding are in place. A critical consideration is the protection of workers in the pipeline in the event of a flood.

2.9.30 Explosive Actuated Fastening Device (Construction Regulation 21)

A contractor may not use or permit any person to use an explosive actuated fastening device, unless-

- The user is provided with and uses suitable protective equipment;
- The user is trained in the operation, maintenance and use of such a device;

- The explosive actuated fastening device is provided with a protective guard around the muzzle end, which effectively confines any flying fragments or particles; and
- The firing mechanism is so designed that the explosive actuated fastening device, will not function unless:
    - it is held against the surface with a force of at least twice its weight; and
    - the angle of inclination of the barrel to the work surface is not more than 15 degrees from a right angle.

A contractor must ensure that:

- Only cartridges suited for the relevant explosive actuated fastening device, and the work to be performed, are used;
- An explosive actuated fastening device is cleaned and examined daily before use and as often as may be necessary for its safe operation by a competent person who has been appointed for that purpose;
- The safety devices of an explosive actuated fastening device are in good working order prior to use;
- When not in use, an explosive actuated fastening device and its cartridges are locked up in a safe place, which is inaccessible to unauthorized persons;
- An explosive actuated fastening device is not stored in a loaded condition;
- A warning notice is displayed in a conspicuous manner in the immediate vicinity wherever an explosive actuated fastening device is used; and
- The issuing and collection of cartridges and nails or studs of an explosive actuated fastening device are:
    - controlled and done in writing by a person having been appointed in writing for that purpose; and
    - recorded in a register by a competent person and that the recipient has accordingly signed for the receipt thereof as well as the returning of any spent and unspent cartridges.

The Explosive Actuated Fastening Device Supervisor shall supervise the use and maintenance of Explosive Actuated Fastening Device.

2.9.31 Fall Protection (Construction Regulation 10)

The Fall Protection Supervisor shall take the necessary steps to protect all persons working in a fall risk position.

The Fall Protection Supervisor must develop a Fall Protection Plan that shall be included in the Contractor's Method Statement and include:

- An index of fall risks identified for the project. This index is to be kept updated at all times as additional risks are revealed during construction;

- A Risk Assessment of all work carried out from a fall risk position and the procedures and methods used to address all the risks identified per location;
- The processes for the evaluation of the employees' medical fitness necessary to work at a fall risk position and the records thereof;
- The syllabus and programme for the training of employees working from fall risk positions and the records thereof; and
- The procedure addressing the inspection, testing and maintenance of all fall protection equipment.

All persons working in a fall risk position shall be medically examined to confirm that they are fit to work at heights.

2.9.32 Structures (Construction Regulation 11)

The contractor shall supervise the erection of any structures.

The designer shall carry out inspections at appropriate stages to verify that the construction of the relevant structure is carried out in accordance with the design and must stop any contractor from executing any construction work which is not in accordance with the relevant design's OH&S aspects.

The Contractor shall ensure that in terms of Construction Regulation 11:

- That the structure on/in which works is to be performed has been inspected by a structural engineer declaring the structure to be safe for use for the intended work processes;
- Steps are taken to ensure that no structure becomes unstable or poses a threat of collapse due to demolition and construction work being performed on it, or in the vicinity of it, including excavations and blasting operations;
- No structure is overloaded to the extent where it becomes unsafe. If uncertainty arises then the structural engineer is to be consulted. During construction the structural engineer's maximum construction slab loading is to be complied with;
- He/she has received from the designer the following information:
    - Information on known or anticipated hazards relating to the construction/demolition work and the relevant information required for the safe execution of the construction/demolition work;
    - A geo-technical report (where applicable);
    - The loading the structure is designed to bear;
    - The methods and sequence of the construction/demolition process; and
    - All drawings pertaining to the design are on site and available for inspection.
- The structural engineer shall carry out inspections at appropriate intervals of the construction work in execution of the design of the relevant structure, to ensure compliance with the design and record the results of these inspections in writing. These records of inspections shall be maintained on the relevant site safety file.

SCHEDULE A: NOTIFICATION OF CONSTRUCTION WORK

(ANNEXURE 2)

OCCUPATIONAL HEALTH AND SAFETY ACT, 1993

(Regulation 4 of the Construction Regulations, 2014)

NOTIFICATION OF CONSTRUCTION WORK

1. (a) Name and postal address of principal contractor:

   _____

   (b) Name and telephone number of principal contractor's contact person:

   _____

2. Principal contractor's compensation registration number:

   _____

3. (a) Name and postal address of client:

   _____

   (b) Name and telephone number of client's contact person or agent:

   _____

4. (a) Name and postal address of designer(s) project:

   _____

   (b) Name and telephone number of designer(s) contact person:

   _____

5. Name and telephone number of principal contractor's construction supervisor on site appointed in terms of regulation 8(1).

   _____

6. Name/s of principal contractor's sub-ordinate supervisors on site appointed in terms of regulation 8(2).

   _____

7. Exact physical address of the construction site or site office:

   _____

8. Nature of the construction work:

   _____

   _____

   _____

9. Expected commencement date:

   _____

10. Expected completion date:

    _____

11. Estimated maximum number of persons on the construction site:

    Total: _____ Male: _____ Female: _____

12. Planned number of contractors on the construction site accountable to the principal contractor:

    _____

13. Name(s) of contractors already selected:

_____

_____

_____

_____

_____

_____

_____ _____

PRINCIPAL CONTRACTOR DATE

_____ _____

CLIENT'S AGENT (where applicable) DATE

_____ _____

CLIENT DATE

- *This document is to be forwarded to the Office of the Department of Labour **prior to commencement of work** on Site.*
- ***All Principal Contractors** that qualify to notify must do so even if another Principal Contractor on the same Site had done so prior to the commencement of work.*

SCHEDULE B: RECORDS TO BE KEPT AVAILABLE ON SITE

ITEM	CR	RECORD TO BE KEPT	RESPONSIBLE PERSON
1.	4(1)	Notification to Provincial Director – Annexure 2 Available on Site.	Principal Contractor
2.	5(1)	Client's Health and Safety Specification Available on Site.	Client's Agent
3.	7(1)(a)	Principal Contractor's Health and Safety Plan in Health and Safety File as well as each Contractor's Health and Safety Plan.	Principal Contractor
4.	7(1)(b)	Health and Safety File opened and kept on Site (including all documentation-required i.t.o. OH&SA and Regulations.	Principal Contractor
5.	7(1)(e)	Consolidated Health and Safety File handed to Client on completion of Construction work. To include all documentation required i.t.o. OH&SA and Regulations and records of all drawings, designs, materials used and similar information on the structure.	Principal Contractor
6.	7(1)(f)	Comprehensive and Updated List of all Contractors on Site, the agreements between the parties and the work being done Included in the Health and Safety file.	Principal Contractor
7.	7(1)(a)	Keep a record on the Health and Safety File of the input by the Construction Safety Officer [CR 8 (5)] at design stage or on the Health and Safety Plan.	Principal Contractor
8.	9(1)	Baseline and Issue based Risk Assessments on Health and Safety File.	Risk Assessor
9.	7(7)	Proof of Health and Safety Induction Training.	Principal Contractor
10.	10(1)	Construction Manager [CR 8(1)] has latest updated version of Fall Protection Plan [CR 10(1)].	Fall Protection Plan Developer
11.	6(1)(d) & 5(1)(r)	Inform Principal Contractor in writing of dangers and hazards relating to construction work.	Designer of Structure/Client
12.	11(1)(c)	All drawings pertaining to the design of structure on Site available for inspection.	Principal Contractor
13.	6(1)(g)	Record of inspection of the structure by the Designer or delegated engineer.	Designer of Structure
14.	11(2)(b)	Record of inspection of the structure [First 2 years – once every 6 months, thereafter yearly].	Owner of Structure
15.	11(2)(d)	Maintenance records – safety of structure available on request.	Owner of Structure

ITEM	CR	RECORD TO BE KEPT	RESPONSIBLE PERSON
16.	6(2)(c)	Drawings pertaining to the design of formwork / support work structure in Health and Safety File.	Formwork/Support Work Supervisor
17.	13(2)(h)	Record of daily excavation inspections on Health and Safety File.	Excavator
18.	17(11)	Suspended Platform inspection and performance test records kept on Site available on request.	Not applicable
19.	19(8)(c)	Material Hoist daily inspection entered and signed in record book kept on the premises.	Not applicable
20.	19(8)(d)	Maintenance records for Material Hoist available on Site.	Not applicable
21.	20(8)	Records of Batch Plant maintenance and repairs on Site available for inspection.	Bulk Mixing Plant Supervisor
22.	21(2)(g)	Issuing and collection of cartridges and nails or studs for Explosive Actuated Fastening Devices, recorded in register – recipient signed for receipt as well as return.	Explosive Actuated Fastening Devices Supervisor
23.	23(1)(k)	Daily inspections (prior to use) of Construction Vehicles and Mobile Plant.	Drivers/Operators
24.	24(d)	Record of temporary electrical installation inspections [once a week] and electrical machinery [daily before use] in a register and kept on Site.	Electrical Supervisor
25.	Driven and General Machinery Regulation	Record of daily inspections of machinery. Record of other inspections of machinery.	Users of machinery Person responsible for machinery

SCHEDULE C: RISK ASSESSMENT CHECKLIST

(Based on the Construction Regulations of the Occupational Health and Safety Act)

* Denotes items applicable to both Construction Sites, Contractor Plant and storage yards.

ELEMENT	REMARKS
1. Administrative and legal requirements	
2. Education, training and promotion	
3. Public safety, security measures and emergency preparedness	
4. Personal protective equipment	
5. Housekeeping	
6. Working at heights (including roof work)	
7. Scaffolding, formwork and support work	
8. Ladders	
9. Electrical safeguarding	
10. Emergency, fire prevention and protection	
11. Excavations and demolition	
12. Tools	
13. Cranes	
14. Builder’s hoist	
15. Transport and materials handling equipment	
16. Site Plant and machinery	
17. Plant and storage yard or Site workshop specifics	
18. Workplace environment, health and hygiene	

1. ADMINISTRATIVE AND LEGAL REQUIREMENTS

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
Construction Regulation 4	**Notice of carrying out construction work**	Department of Labour notified. Copy of notice available on Site.	
General Admin Regulation 4	***Copy of OH&S Act**	Updated copy of the OH&S Act and Regulations on Site. Readily available for perusal by all employees.	
Construction Regulation 7(1)(c)(iv)	***Registration with Compensation Commissioner or other approved compensation insurer**	Written proof of registration/Letter of good standing available on Site.	
Construction Regulation 5(1) & 7(1)	**OH&S ACT specification, plans and programme**	OH&S ACT spec received from TCTA. OH&S ACT plan developed. OH&S ACT programme implemented. Plans and programme updated regularly.	
Section 8(2)(d) Construction Regulation 9	***Hazard identification and Risk Assessment**	Hazard identification carried out and recorded. Risk Assessment and plan drawn up and updated. Employees and Contractors informed and trained.	
Section 16(2)	***Assigned duties (Managers)**	Responsibility of complying with the OH&S ACT assigned to another person/s by CEO.	
Construction Regulation 8(1)	**Designation of person responsible on Site**	Competent person appointed in writing as Construction Manager.	
Construction Regulation 8(7)	**Designation of assistant for responsible person**	Competent person appointed in writing as Construction Supervisor.	
Section 17 and 18 and General Administrative Regulations 6 and 7	***Election and designation of occupational health and safety Representatives**	More than 20 employees - one representative and one additional representative for each 50 employees or part thereof. Designation in writing, period and area of responsibility specified. Meaningful reports.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
		Reports actioned by management.	
Section 19 and 20 and General Administrative Regulations 5	***Occupational health and safety committee/s**	Committee/s established. Members appointed in writing. Meetings held monthly. Minutes kept. Actioned by management.	
Section 37(1) and (2)	***Agreement with mandatories, Contractors and Contractors**	Written agreement with contractors and Contractors. List of contractors and Contractors displayed. Proof of Registration with Compensation Commissioner or Compensation Insurer as well as Letter of Good Standing. Construction Supervisor designated. Written arrangements regarding represen-tatives and committee. Written arrangements regarding first-aid.	
Section 24 and General Administrative Regulation 8 COID Act Section 38, 39 and 41	***Reporting of incidents (Department of Labour)**	Incident reporting procedure displayed. All incidents in terms of section 24 reported to the Provincial Director, Department of Labour, within 3 days (Annexure 1 and/or WCL 1 or 2). Cases of occupational disease reported. Copies of reports available on Site. Record of first-aid injuries kept.	
General Administrative Regulation 9	***Investigation and recording of incidents**	All injuries which resulted in the person receiving medical treatment other than first aid, recorded and investigated by investigator designated in writing. Copies of reports (Annexure 1) available on Site. Tabled at committee meeting. Action taken by Site management.	
Construction Regulation 10	**Fall prevention and protection**	Competent person appointed to draw up and supervise the Fall Protection Plan. Proof of appointees' competence available on Site. Risk Assessment carried out for work at heights. Fall Protection Plan drawn up and updated. Plan available on Site.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
Construction Regulation 10(5)	**Roof work**	Competent person appointed to plan and supervise roof work. Proof of appointees' competence available on Site. Risk Assessment carried out. Roof work plan drawn up and updated. Roof work inspect before each shift and inspection register kept. Employees medically examined for physical and psychological fitness and written proof on Site.	
Construction Regulation 11	**Structures**	Information regarding the structure being erected received from the Designer including: • Geo-science technical report where relevant; • The design loading of the structure; • The methods and sequence of construction; and • Anticipated dangers, hazards and/or special measures to construct safely. Risk Assessment carried out. Method Statement drawn up. All above available on Site. Structures inspected before each shift. Inspection register/s kept.	
Construction Regulation 12	**Formwork and support work**	Competent person appointed in writing to supervise erection, maintenance, use and dismantling of support and formwork. Design drawings available on Site. Risk Assessment carried out. Support and formwork inspected: • Before use and inspection; • Before pouring of concrete; • Weekly whilst in place; and • Before stripping or dismantling and Inspection register/s kept.	
Construction Regulation 16	**Scaffolding**	Competent persons appointed in writing to: • Erect scaffolding (scaffold erector/s);	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
		• Act as scaffold team leaders; and • Inspect scaffolding weekly and after inclement weather (scaffold inspector/s). Written proof of competence of above appointees. Appointees available on Site. Copy of the applicable SANS standard available on Site. Risk Assessment carried out. Inspected weekly and/or after bad weather. Inspection register/s kept.	
Construction Regulation 17	**Suspended platforms**	Competent persons appointed in writing to: • Control the erection of suspended platforms; • Act as suspended platform team leaders; and • Inspect suspended scaffolding weekly and after inclement weather. Risk Assessment conducted. Certificate of authorisation issued by a registered professional engineer available on Site and copy forwarded to the Department of Labour. The following inspections of the whole installation carried out by a competent person: • After erection and before use; • Daily prior to use; and • Inspection register/s kept. The following tests to be conducted by a competent person: • Load test of whole installation and working parts every 12 months; and • Hoisting ropes, hooks and load attaching devices quarterly; and • Tests logbook kept. Employees working on suspended platforms should be medically examined for physical and psychological fitness. Written proof available.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
Construction Regulation 13	**Excavations**	Competent person/s appointed in writing to supervise and inspect excavation work. Written proof of competence of above appointee/s available on Site. Risk Assessment carried out. Excavations inspected: • Before every shift; • After any blasting; • After an unexpected fall of ground; • After any substantial damage to the shoring; and • After rain. Inspection register/s kept. Method Statement developed where explosives will be and/or are used.	
Construction Regulation 14	**Demolition work**	Competent person/s appointed in writing to supervise and control demolition work. Written proof of competence of above appointee/s available on Site. Risk Assessment carried out. Engineering survey and method Statement available on Site. Inspections to prevent premature collapse carried out by competent person before each shift. Inspection register/s kept.	
Construction Regulation 19	**Materials hoist**	Competent person appointed in writing to inspect the material hoist. Written proof of competence of above appointee available on Site. Materials hoist to be inspected weekly by a competent person. Inspection register/s kept.	
Construction Regulation 26	**Water environments (including caissons and cofferdams)**	Competent person appointed in writing to supervise, control and inspect work on or over water and the construction, installation, and dismantling of caissons and/or cofferdams. Written proof of competence of above appointee available on Site.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
		Risk Assessment carried by a competent person on a daily basis. Inspection register/s kept.	
Construction Regulation 21	**Explosive Actuated Fastening Devices**	Competent person appointed to control the issue of the Explosive Actuated Fastening Devices and cartridges as well as the service, maintenance and cleaning. Register kept of above. Empty cartridge cases, nails and fixing bolts returns recorded. Cleaned daily after use.	
Construction Regulation 20	**Bulk Mixing Plant**	Competent person appointed to control the operation of the Batch Plant as well as the service, maintenance and cleaning of this Plant. Register kept of above. Risk Assessment carried out. Batch Plant to be inspected weekly by a competent person and inspections register/s kept.	
Construction Regulation 15 and Mine Health and Safety Act	**Tunnelling**	Complying with Mines Health and Safety Act (29 of 1996). Risk Assessment carried out.	
Construction Regulation 22 Driven Machinery Regulations 18 and 19	**Cranes and lifting machines equipment**	Competent person appointed in writing to inspect cranes, lifting machines and equipment. Written proof of competence of above appointee available on Site. Cranes and lifting tackle identified and numbered. Register kept for lifting tackle. Logbook kept for each individual crane. Inspection: • **All cranes:** Daily by operator; • **Tower cranes:** After erection and thereafter 6 monthly; • **Other cranes:** Annually by competent person; and	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
		• **Lifting tackle (slings, ropes, chain slings etc.):** Three monthly.	
Construction Regulation 24 Electrical Machinery Regulations 9 and 10 Electrical Installation Regulations	***Inspection and maintenance of electrical installation and equipment (including portable electrical tools)**	Competent person appointed in writing to inspect/test the installation and equipment. Written proof of competence of above appointee available on Site. Inspections: • Electrical installation and equipment inspected after installation, alterations and quarterly thereafter. Inspection register/s kept; • Portable electric tools and lights and extension leads identified/numbered; and • Monthly visual inspection by user, issuer or storeman. Register/s kept.	
Diving Regulations	**Diving operations**	Competent person appointed in writing to supervise diving operations and ensure maintenance, statutory inspection and testing by an approved inspection authority of equipment used. Written proof of competence of above appointee available on Site. Proof of registration of all divers present on Site available. Risk Assessment carried out. Diving manual produced and available on Site. Record of voice communications kept. Diving operations record kept. Each diver keeps a personal logbook and entries countersigned by the Diving Supervisor. Decompression tables available on Site. Records of any decompression illness kept. Certificate of manufacture of any compression chamber or diving bell in use available on Site.	
Construction Regulation 28 General Safety Regulation	***Designation of Stacking and Storage Supervisor**	Competent persons with specific knowledge and experience designated to supervise all stacking and storage. Written proof of competence of above appointee available on Site.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
8(1)(a)			
Construction Regulation 29 Environmental Regulation 9	***Designation of a person to coordinate emergency planning and fire protection**	Person/s with specific knowledge and experience designated to coordinate emergency contingency planning and execution and fire prevention measures. Emergency evacuation plan: • Developed and available on Site; • Drilled and practiced; and • Records of drills and practices available on Site. Fire Risk Assessment carried out. All fire extinguishing equipment: • Identified and on register; • Inspected weekly and inspection registers kept; • Replaced after use; and • Serviced annually.	
General Safety Regulation 3	***First-aid**	Every workplace provided with sufficient number of first-aid boxes (required where 5 persons or more are employed). First-aid boxes freely available. Content of boxes as per the minimum requirements of the OH&S ACT. One qualified First-aider appointed for every 50 employees (required where more than 10 persons are employed). List of First-aiders and competency certificates available on Site. Name and contact details of person in charge of first-aid box clearly displayed. Location of first-aid boxes clearly demarcated. Signs instructing employees to report all injuries and/or illness including first-aid injuries.	
General Safety Regulation 2	**Personal protective equipment (PPE)**	PPE Risk Assessment carried out. Items of PPE prescribed, and use enforced. Records of issue kept. Undertaking by employee to use and/or wear PPE.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
General Safety Regulation 9	***Inspection and use of welding and/or flame cutting equipment**	Competent person/s with specific knowledge and experience designated to inspect electric arc, gas welding and flame cutting equipment. Written proof of competence of above appointee available on Site. Equipment identified/numbered and entered into a register. Equipment inspected monthly. Inspection register/s kept.	
Hazardous Chemical Substances (HCS) Regulations Construction Regulation 25	***Control of storage and usage of HCS and other flammables**	Competent person/s with specific knowledge and experience designated to control the storage and usage of HCS (including flammables). Written proof of competence of above appointee available on Site. Risk Assessment carried out. Register of HCS kept and/or used on Site.	
Pressure Equipment Regulations	Pressure Equipment	Competent Person/s with specific knowledge and experience designated to supervise the use, storage, maintenance, statutory inspections and testing of Pressure Equipment. Written proof of competence of above appointee available on Site. Risk Assessment carried out. Certificates of manufacture available on Site. Register of Pressure Equipment on Site. Inspections and testing by approved inspection authority (AIA): • After installation, re-erection or repairs; • Every 36 months; and • Register or log kept of inspections, tests, modifications and repair on Site.	
Construction Regulation 23	**Construction vehicles and earth moving equipment**	Operators or drivers appointed to: • Carry out a daily inspection prior to use; and • Drive the vehicle or Plant that he/she is competent to drive or operate. Written proof of competence of above appointee available on Site.	

OH&S Act Section Regulation	Subject	Requirements	Yes/ No
		Record of daily inspections kept on Site.	
General Safety Regulation 13A	***Inspection of Ladders**	Competent person appointed in writing to inspect ladders. Ladders inspected at arrival on Site and monthly thereafter. Inspection register/s kept on Site.	
General Safety regulation 13B	**Ramps**	Competent person appointed in writing to supervise the erection and inspection of ramps. Inspection register/s kept on Site.	

2. EDUCATION, TRAINING AND PROMOTION

Subject	Requirement	Yes/ No
***Occupational Health and Safety Policy as per OH&S ACT Section 7(1)	Policy signed by CEO and published and communicated to employees. Policy displayed on employee notice boards. Management and employees committed.	
***Company and Site health and safety rules as per OH&S ACT Section 13(a)	Rules published. Rules displayed on employee notice boards. Rules issued and explained to employees with written proof thereof. Follow-up to ensure employees understand and adhere to the rules.	
***Induction and task safety training as per OH&S ACT Section 13(a)	All new employees receive health and safety induction training. Training includes task safety instructions. Employees acknowledge receipt of training. Follow-up to ensure employees understand and adhere to instructions.	
***General health and safety training as per OH&S ACT Section 13(a)	All employees receive basic health and safety training. Written proof kept. Operators of Plant and equipment receive specialised training. Follow-up to ensure employees understand and adhere to instructions.	
***Occupational health and safety promotion	Incident experience board indicating among others - Number of hours worked without an injury; and Number of days worked without an injury. Safety grading - Board kept up to date.	

Subject	Requirement	Yes/ No
	Relevant safety posters displayed and changed regularly. Employee notice board for health and safety notices. Site health and safety competitions. Company health and safety competition. Participation in regional health and safety competitions. Suggestion scheme.	

3. PUBLIC SAFETY, SECURITY MEASURES AND EMERGENCY PREPAREDNESS

Subject	Requirement	Yes/ No
***Notices and signs	Notices and signs at entrances along perimeters indicating **"No unauthorised entry"** and **"Entry at own risk"**. Notices and signs at entrance instructing visitors and non-employees what to do, where to go and where to report on entering the Site or yard with directional signs for example: **"Visitors to report to office"**. Notices and signs posted to warn of overhead work and other hazardous activities for example: **General Warning Signs**.	
Site safeguarding	Nets, canopies, stills, fans etc. to protect members of the public passing and/or entering the Site.	
***Security measures	Access control measures and register in operation. Security patrols after hours and weekends. Sufficient lighting after dark. Guard has access to telephone or other means of emergency communication.	
***Emergency preparedness	Emergency contact numbers displayed near telephone. Emergency evacuation instructions posted up on all notice boards (including employees' notice boards). Emergency contingency plan available on Site or in yard. Doors open outwards and unobstructed. Emergency alarms audible all over (including in toilets).	
*Emergency drill and evacuation	Adequate number of employees trained to use fire equipment. Emergency evacuation plan available, displayed and practiced. **(See Section 1 for designation and register)**.	

4. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Subject	Requirement	Yes/ No
*****PPE needs analysis	Need for PPE identified and prescribed in writing.	
*****Head protection	It is compulsory for all persons on Site to wear safety helmets including Contractors and visitors (where prescribed).	
*****Foot protection	All persons on Site have to wear safety footwear including gumboots for concrete or wet work and non-slip shoes for roof work.	
*****Eye and face protection	Eye and face protection (such as goggles, face shields, welding helmets) to be used when operating the following: • Jack or kango hammers; • Angle or bench grinders; • Electric drills (overhead work into concrete, cement and bricks); • Explosive powered tools; • Concrete vibrators or pokers; • Hammers and chisels; • Cutting or welding torches; • Arc welding equipment; • Skill or bench saws; and • Spray-painting equipment etc.	
*****Hearing protection	Hearing Protectors (such as muffs, plugs) used when operating the following: • Jack or kango hammers; • Explosive powered tools; and • Wood or aluminum working machines such as saws, planers, routers.	
*****Hand protection	Protective gloves to be worn by employees handling or using: • Cement, bricks, steel or chemicals; • Welding equipment; • Hammers and chisels; and • Jack or kango hammers etc.	
*****Respiratory protection	Suitable and efficient respirators to be worn correctly by employees handling or using: • Dry cement; • Dusty areas; • Hazardous chemicals; • Angle grinders; and	

Subject	Requirement	Yes/ No
	• Spray-painting etc.	
*****Fall Prevention Equipment	Suitable safety belts or fall arrest equipment correctly used by persons working on or in unguarded, elevated positions such as: • Scaffolding; • Riggers; • Lift shafts; • Edge work; and • Ring beam edges etc. Other applicable methods of fall prevention should all be applied such as catch nets.	
*****Protective clothing	All jobs requiring protective clothing (such as overalls, rain wear, welding aprons etc.) to be identified and clothing worn.	
*****PPE issue and control	Identified equipment to be issued free of charge. All PPE should be maintained in good condition (i.e. regular checks). Workers instructed in the proper use and maintenance of PPE. Commitment obtained from wearer accepting conditions and to wear the PPE. Record of PPE issued kept on file.	

5. HOUSEKEEPING

Subject	Requirement	Yes/ No
*****Scrap removal system	All items of scrap, unusable off cuts, rubble and redundant material removed from working areas on a regular basis. Scrap and/or waste removal from heights by chute, hoist or crane (i.e. nothing thrown or swept over sides). Scrap disposed of in designated containers or areas. Removal from Site or yard on a regular basis.	
Stacking and storage **(See Section 1 for designation and register)**	Stacking: • Stable; • On firm level surface or base; • Not leaning and/or collapsing; • Irregular shapes bonded; • Not exceeding 3 times the base; • Stacks accessible; and • Removal from top only. Storage:	

	• Adequate storage areas provided; • Functional for example demarcated storage areas, racks, bins etc.; • Special areas identified and demarcated for example flammable gas, cement etc.; • Neat, safe, stable and square; • Store and storage areas clear of superfluous material; • Storage behind sheds etc. should be neat and under control; and • Storage areas free from weeds, litter, etc.	
***Waste control or reclamation	Re-usable off cuts and other re-useable material removed daily and kept to a minimum in the work areas. All re-useable materials neatly stacked or stored in designated areas (i.e. nails removed or bent over in re-useable timber). Issue of hardware, nails, screws and cartridges etc. should be controlled and return of unused items monitored.	
Contractors	Contractors to comply with the Site or yard's housekeeping requirements.	

6. WORKING AT HEIGHTS (INCLUDING ROOF WORK)

Subject	**Requirement**	**Yes/ No**
Openings	Unprotected openings adequately guarded, fenced and barricaded with catch nets installed where necessary. Covers over openings in roof of robust construction and secured against displacement.	
General requirements	Roof work discontinued when bad or hazardous weather prevails. Fall protection measures (including warning notices) when working close to edges or on fragile roofing material.	

7. SCAFFOLDING, FORMWORK AND SUPPORT WORK

Subject	**Requirement**	**Yes/ No**
Access and system scaffolding **(See Section 1 for designation and register)**	Foundation firm and stable. Sufficient bracing. Tied to structure and secured from side or cross movement. Platform boards in good condition and secured. Sufficient platform boards to be used. Handrails and toe boards provided.	

Subject	Requirement	Yes/ No
	Access ladders or stairs provided. Area/s under scaffolding tidy. Safe and unsafe for use signs to be used. Complying with OH&S ACT and the applicable SANS standard.	
Free standing scaffolding	Foundation firm and stable. Sufficient bracing. Platform boards in good condition and secured. Sufficient platform boards to be used. Handrails and toe boards provided. Access ladders or stairs provided. Area/s under scaffolding tidy. Safe or unsafe for use signs to be used. Height and base ratio correct. Outriggers used and tied to structure where necessary. Complying with OH&S ACT and the applicable SANS standard.	
*****Mobile scaffolding	Foundation firm and stable. Sufficient bracing. Platform boards in good condition and secured. Sufficient platform boards to be used. Handrails and toe boards provided. Access ladders or stairs provided. Area/s under scaffolding tidy. Safe and unsafe for use signs to be used. Wheels and swivels in good condition. Brakes working and applied. Height to base ratio correct. Outriggers used where necessary. Complying with OH&S ACT and the applicable SANS standard.	
Suspended scaffolding	Outriggers securely supported and anchored. Correct number of steel wire ropes used. Platform as close as possible to the structure. Handrails on all sides. All winches, ropes, cables and brakes inspected regularly. Inspection registers kept on Site. Scaffolding complies with OH&S ACT. Winches maintained by competent person.	
Formwork and support work	All components in good condition. Foundation firm and stable. Adequate bracing and stability ensured. Good workmanship, uprights straight and plum.	

Subject	Requirement	Yes/ No
	Good cantilever construction. Safe access provided. Areas under support work tidy. Same standards as for system scaffolding.	
Special scaffolding	Special scaffolding for example cantilever, jib and truss-out scaffolds erected to an acceptable standard and inspected by specialists. Inspection registers to be kept on Site.	
Edges and openings	Edges barricaded to acceptable standards. Manhole openings covered and/or barricaded. Openings in floor and other openings covered, barricaded or fenced. Stairs provided with handrails. Lift shafts barricaded or fenced off.	

8. LADDERS

Subject	Requirement	Yes/ No
*Physical condition, use and storage **(See Section 1 for designation and register)**	Stepladders – hinges, stays, braces and stiles in order. Extension ladders – ropes, rungs, stiles, safety latch and hook in order. Extension or straight ladders secured or tied at the bottom or top. No joined ladders used. All ladders stored on hooks or racks and not on ground. Ladders protrude 900 mm above landings, platforms or roof. Fixed ladders higher than 5 m have cages or fall arrest system.	

9. ELECTRICAL SAFEGUARDING

Subject	Requirement	Yes/ No
***Electrical distribution boards and earth leakage	Colour coded, numbered and symbolic sign displayed. Area in front kept clear and unobstructed. Fitted with inside cover plate, openings blanked off and no exposed “live” conductors or terminals. Door kept closed. Switches and/or circuit breakers identified. Earth leakage protection unit fitted and operating. Tested with instrument - test results within.	

Subject	Requirement	Yes/ No
	15 – 30 milli-amps. Aperture openings provided for the plugging in and removal of extension leads without the need to open the door.	
*****Electrical installations and wiring	Temporary wiring or extension leads in good condition with no bare or exposed wires. Earthing continuity and polarity correct: **"Brown is live, Blue is neutral, Green and Yellow earth the lot"** Cables protected from mechanical damage and moisture. Correct loading observed for example no heating appliance used from lighting circuit etc. Light fittings and lamps protected from mechanical damage/moisture.	
*****Physical condition of electrical appliances and tools	Electrical equipment and tools (includes all items plugging into a 15 Amp supply socket): • Insulation and casing in good condition; • Earth wire connected or intact where not of double insulated design; • Double insulation mark where no earth wire; • Cord in good condition / no bare wires / secured to machine and plug; and • Plug in good condition, connected correctly and correct polarity.	

10. FIRE AND HAZARDOUS SUBSTANCES

Subject	Requirement	Yes/ No
*****Fire extinguishing equipment **(See Section 1 for designation and register)**	Fire Risks Identified and on record. Fire Extinguishing Equipment available for: • Offices; • General stores; • Flammable store; • Fuel storage tanks; • Gas welding or cutting operations; and • Where flammable substances are being used or applied.	
*****Maintenance	Fire equipment serviced minimum annually, but preferably 6 monthly.	
*****Location and	Fire extinguishing equipment:	

Subject	Requirement	Yes/ No
Signs	• Clearly visible; • Unobstructed; and • Sign posted including “No Smoking” and “No Naked Lights” where required i.e. (flammable store, gas store, fuel tanks etc.).	
***** Storage issue and control of flammables (incl. gas cylinders)	Storage area provided for flammables with suitable doors, ventilation, bund etc. Flammable store neat and tidy with no Class A combustibles. Decanting of flammable substances carried out in ignition free and adequately ventilated area. Container bonding principles applied. Only sufficient quantities issued for one day’s use. Special gas cylinder store or storage area. Gas cylinders stored, used and transported upright and secured in trolley, cradle or structure that is well ventilated. Types of gas cylinders identified and stored separately. Full cylinders stored separately from empty cylinders.	
*****Storage, issue and control of Hazardous Chemical Substances (HCS) **(See Section 1 for designation and register)**	All substances identified and list available e.g., acids, flammables, poisons etc. Material Safety Data Sheets (MSDS) indicating hazardous properties and emergency procedures in case of incident on file and readily available. Substances stored safely. HCS storage principles applied i.e., products segregated. Provision made for leakage and spillage containment. Emergency (serviceable) showers and eye wash facilities provided. HCS under lock and key as well as controlled by designated person. Decanted or issued in containers with information and warning labels. Disposal of unwanted HCS by recognised disposal agent.	

11. EXCAVATIONS

Subject	Requirement	Yes/ No
Excavations deeper than 1.5 m.	Shored or braced to prevent caving or falling in. Provided with an access ladder. Excavations guarded, barricaded or lighted after dark in public	

Subject	Requirement	Yes/ No
(See Section 1 for designation and register)	areas. Soil dumped at least 1 m away from edge of excavation. On sloping ground soil dumped on lower side of excavation.	

12. HAND TOOLS

Subject	Requirement	Yes/ No
***Hand tools	Shovels, spades and picks: • Handles free from cracks and splinters; • Handles fit securely; and • Working end sharp and true. Hammers: • Good quality handles, no pipe or reinforcing steel handles; • Handles free from cracks and splinters; and • Handles fit securely. Chisels: • No mushroomed heads or heads chamfered; • Not hardened; and • Cutting edge sharp and square. Saws: • Teeth sharp and set correctly; and • Correct saw used for the job.	
***Explosive powered tools **(See Section 1 for designation and register)**	Only used by trained and authorised personnel. Prescribed warning signs placed or displayed where tool is in use. Inspected at least monthly by competent person and results recorded in on Site register. Issue and return recorded including cartridges or nails and unused cartridges, nails, empty shells recorded. Cleaned daily after use in on Site register.	

13. CRANES

Subject	Requirement	Yes/ No
Tower crane **(See Section 1 for designation and register)**	Only operated by trained authorised operator with valid certificate of training. Certificate available on Site. Structure - no visible defects.	

Subject	Requirement	Yes/ No
	Electrical installation good and safe. Crane hook - throat pop marked, safety latch fitted and functional. SWL/MML displayed. Limit switches fitted and operational. Access ladder fitted with backrests or fall arrest system installed. Lifting tackle in good condition and inspection colour coding current.	
*****Mobile crane **(See Section 1 for designation and register)**	Only operated by trained authorised operator with valid certificate of training. Certificate available on Site. Rear view mirrors and windscreen visibility good. Windscreen wipers operating effectively. Indicators operational. Hooter working. Tyres safe with sufficient tread and pressure visibly sufficient. No missing wheel nuts. Headlights, taillights operational. Grease nipples and grease on all joints. No visible oil leaks. Hydraulic pipes visibly sound with no leaks. No undue corrosion on battery terminals. Boom visibly in good condition with no apparent damage. Cable and sheaves greased with no visible damage, split wires or corrosion. Brakes working properly. Crane hook - throat pop marked, safety latch fitted and functional. SWL/MML displayed. By-pass valves operational. Deflection chart displayed and visible to operator or driver. Outriggers functional used.	
*Gantry crane	Only operated by trained authorised persons. Correct slinging techniques used. Recognised displayed on chart signals used. Log book kept up to date. Prescribed inspections conducted on crane and lifting tackle. “Crane overhead” signage, where applicable. Crane hook - throat pop marked, safety latch fitted and functional. SWL/MML displayed and load limiting switches fitted and operational.	

14. BUILDER'S HOIST

Subject	Requirement	Yes/ No
Builder's hoist **(See Section 1 for designation and register)**	**"Hoist in operation"** - sign displayed. General construction strong and free from latent defects. Tower: • Adequately secured and braced; • At least 900 mm available for over travel; • Barricaded at least 2 100 mm high at ground level and floors; and • Landing place provided with gate at least 1 800 mm high. Platform: • No persons conveyed on platform; • Steel wire ropes with breaking strain of six times maximum weight; • Signal systems used; • Goods prevented from moving/falling off; and • Effective brake capable of holding maximum weight.	

15. TRANSPORT AND MATERIALS HANDLING EQUIPMENT

Subject	Requirement	Yes/ No
***Site vehicles	All Site vehicles, dumpers, bobcats, loaders etc. checked daily before use by driver or operator. Inventory of vehicles used/operated on Site. Inspection by means of a checklist and results recorded. No persons riding on equipment not designed for passengers. Site speed limit posted and not exceeded. Drivers and operators trained and licensed. Licenses available on Site. No unauthorised persons driving or operating equipment.	
Conveyors	Conveyor belt nip points and drive guarded. Emergency stop and lever brake fitted, clearly marked and accessible.	

16. SITE PLANT AND MACHINERY

Subject	Requirement	Yes/ No
Brick cutting machine	Operator trained and only authorised persons use the machine. Emergency stop switch clearly marked and accessible. Area around the machine dry and slip or trip free as well as clear of off cuts. All moving drive parts guarded. Electrical supply cable protected. Operator using correct PPE i.e. eye, face, hearing, foot, hands and body.	
*****Electric arc welder	Welder trained. Only authorised and trained persons use welder. Adequately earthed. Electrode holder in good condition and safe. Cables, clamps, lugs and connectors in good condition. Area in which welding machine is used is dry and protected from wet. Welder using correct PPE i.e. eye, face, foot, body and respiratory. Screens and warning signs placed.	
*****Woodworking machines	Operator's trained and only authorised persons use machines. Provided with guards and guards used. Operators using correct PPE i.e., eye, face, foot and hearing.	
*****Compressors	Relief valves set, locked and sealed. Maximum safe working pressure (MSWP) indicated on face of pressure gauge face and not on glass cover. All drives adequately guarded. Receiver and lines drained daily. Hoses good condition and clamped, not wired.	
Concrete mixer and batch Plant	Top platform provided with guardrails. Dust abatement methods in use. Operators using correct PPE i.e., eye, hands and respiratory. All moving drive parts guarded. Emergency stops identified, indicated and accessible. Area kept clean, dry and free from tripping and slipping hazards. Banksman identified and crane signals displayed and used.	

18. PLANT AND STORAGE YARD OR SITE WORKSHOP SPECIFICS

Subject	Requirement	Yes/ No
OH&S ACT, Section 8(2)(1) General Machinery Regulation 2(1) **Supervision of the use and maintenance of machinery**	Persons with specific knowledge and experience designated to supervise the use and maintenance of machinery. Critical items of machinery identified, numbered and placed on register or inventory. Inspection or maintenance schedules for abovementioned. Inspections or maintenance carried out to above schedules. Results recorded.	
General Machinery Regulation 9(2) **Notices regarding operation of machinery**	Schedule D notice posted in work areas.	
Pressure Equipment Regulation 13(1)(b) **Supervision of the use and maintenance of** Pressure Equipment	Persons with specific knowledge and experience designated to supervise the use and maintenance of Pressure Equipment. Pressure Equipment identified, numbered and placed on register. Manufacturer's plate intact. Inspection or maintenance schedules for abovementioned. Inspections or maintenance carried out to above schedules. Results recorded and test certificates available.	
Lock-out procedure	Lock-out procedure in operation.	
Demarcation and colour coding	Demarcation principles applied. All services, pipes, electrical installation, stop-start controls, emergency controls etc. colour coded to own published or the applicable SANS standard. Employees trained to identify colour coding.	
Portable and bench grinders	Area around grinder clear and trip/slip free. Bench grinders mounted securely and grinder generally in good condition. No excessive vibration. On and off switch or button clearly demarcated and accessible. Adequate guards in place.	

Subject	Requirement	Yes/ No
	Tool rest – secure, square and maximum 2 mm gap. Stone or disk - correct type and size, mounted correctly and dressed. Use of eye protection enforced.	
Ancillary lifting equipment	Chain blocks, tirfors, jacks and mobile gantries etc. identified and numbered on register. Chains in good condition and links no excessive wear. Lifting hooks – throat pop marked, and safety latch fitted. SWL/MML marked or displayed.	
Presses, guillotines and shears	Only operated by trained and authorised persons. PPE used by operators. Interlocks or lockouts fitted.	

19. ERGONOMICS

Subject	Requirement	Yes/ No
Ergonomics	Ergonomics survey conducted. Results on record. Survey results applied.	
***** Lighting	Adequate lighting in places where work is being executed for example stairwells and basements or after sunset. Light fittings placed and installed causing no irritating or blinding glare.	
***** Ventilation	Adequate ventilation, extraction and exhausting in hazardous areas for example where chemicals and adhesives are stored, welding takes place and where petrol or diesel motors are running in confined spaces or basements.	
***** Noise	Tasks identified where noise exceeds 85 dB(A). All reasonable steps taken to reduce noise levels at the source. Hearing protection used where noise levels could not be reduced to below 85 dBa.	
***** Heat stress	Measures in place to prevent heat exhaustion in heat stress problem areas e.g., steel decks, when the WBGT index reaches 30 (see Environmental Regulation 4). Cold drinking water readily available when extreme temperatures are experienced.	
***** Ablution facilities	Sufficient toilets provided for men and women separately i.e., 1 per 30 employees (National Building Regulations prescribe chemical toilets for construction Sites).	

Subject	Requirement	Yes/ No
	Toilet paper available. Sufficient showers provided for men and women separately. Facilities for washing hands provided. Soap available for washing hands. Means of drying hands available. Changing facilities or area provided for men and women separately. Ablution facilities hygienic and clean.	
*****Eating and cooking facilities	Adequate storage facilities provided. Weather protected eating area provided, separate from changing area. Refuse bins with lids provided. Facilities clean and hygienic.	
*****Pollution of environment	Measures in place to minimize dust generation. Accumulation of empty cement pockets, plastic wrapping or bags, packing materials etc. are prevented. Spillage or discarding of oil, chemicals and diesel into storm water and other drains prevented.	

Name of person who has undertaken the assessment _____

Signature _____

Date _____

Received by _____

Designation _____

Date _____

Tabled at health and safety committee _____

SCHEDULE D: MEASURING INJURY EXPERIENCE

Injury experience has traditionally been measured by the use of a disabling injury frequency rate, the so-called “DIFR”. The DIFR is calculated by multiplying the number of disabling injuries by 1 million and dividing by the number of man-hours worked.

The DIFR has been replaced internationally with a DIIR: disabling injury incidence rate. The only difference between the two rates is that the 1 million in the calculation is replaced with 200 000. (200 000 hours being what a person is purported to work in a working lifetime).

The use of the two rates above has proved to be somewhat problematical being open to manipulation as disabling injuries are often “hidden” by returning the injured employee to the workplace so as not to lose a shift and therefore having to register a disabling injury.

For this project a new frequency rate will be used based on the number of compensation injury claims as these are more difficult to hide or manipulate because the reporting of compensable injuries is a legal requirement.

It is expected that the use of this measurement of injury experience will enable the Construction Industry to monitor itself as far as work related injuries are concerned.

The intention is that it is to be used for measuring injury experience within a company or within the South African Construction Industry whilst the previously mentioned DIIR is to be used when measuring internationally (as required by cross–border Employers).

Below follows an explanation of this rating system.

COMPENSATION INCIDENCE FREQUENCY RATE (CIFR)

FORMULA

**No. of Compensation Claims X **200 000*

***220 man-hours X ****No. of Employees

DEFINITIONS

a) ***No. of Compensation Claims:** The number of claims lodged with the COID insurer for the period under review.

b) ****200 000:** The fixed factor to align the rate with other rates used internationally (200 000 hours is what a person is purported to work in a working lifetime).

c) *****220 man-hours:** The average number of hours worked by one hourly paid employee in one month in the Construction Industry.

d) *****168 man-hours:** The average number of hours worked by one professional staff member in one month.

a) Man-hours worked include:

- Hourly paid employees actual or average (of 220) worked.

- Contractors (No. of Employees X 220 each).
- Professional Staff (No. of Employees X 168 hours each); and
- Overtime, absence on leave or sick leave, unrecorded after-hours time worked by senior and middle management is also factored into this average.

b) ****No. of Employees:** The actual or average number of employees employed for the period under review.

SCHEDULE E: BASELINE RISK ASSESSMENT

IRRESPECTIVE OF THE RISK PRESENTED ON SITE, IT WILL BE ENSURED THAT SUFFICIENT SUPERVISION IS IN PLACE ON SITE, THAT PERSONNEL ARE TRAINED IN ACCORDANCE WITH LEGISLATION, INCLUDING THE REQUIREMENT FOR SITE SPECIFIC INDUCTIONS ON SITE TO INFORM PERSONNEL ON SITE OF THE RISKS AND HAZARDS APPLICABLE TO THE SITE. SITE SUPERVISION IS RESPONSIBLE FOR ENSURING THAT THE CONTROL MEASURES REQUIRED BELOW ARE IMPLEMENTED ON SITE.

	Activity	**RISK**	**HAZARD/MEASURES**
1.	Asphalting	Fire Burns to skin Skin disease	• Not having suitable fire extinguisher to be in place prior to commencement of works • Not having competent personnel using materials and competent and trained machinery/equipment operators • Contractors personnel not wearing suitable and sufficient personal protective equipment (PPE) including safety boots, reflective vests and gloves • No Safety data sheets available
2.	Bricklaying	Caustic contamination with mortar Contact with sharp bladed tools Dermatitis Skin irritations Eye infections from cement dust	• Not using trained personnel • No Safe means of access provided • Unsafe working platforms when working at height • No PPE provided when working with mortar
3.	Brush cutting	Injury from contact with blade/nylon Fire (where petrol used) Electrocution (where electrical tool used)	• Utilising untrained employees for brush cutter • Not using personal protective equipment (PPE) such as goggles, safety boots, ear protection, gloves, hard hat • Brush cutter not maintained • No supervision onsite. • Employees smoking when refuelling, no fire extinguisher available t (where petrol used as fuel source). No drip trays provided when refuelling.
4.	Chainsaw Use	Falling tree or branches causing injury to persons Incorrect use of chainsaw causing injury	• Chainsaw operators not trained • Lack of personal protective equipment (PPE) such as goggles, safety boots, ear protection, gloves, hard hat, chainsaw trousers and jacket • Chainsaw and guards not maintained as per manufacturers requirements • Unsafe work area when using chainsaw • Safe working procedures not communicated to operators of chainsaws. Chainsaw operators not inducted and Fall protection plan not communicated.
5.	Compacting and Filling	Contact with tipping materials Contact with moving plant Vehicles/personnel falling into excavations Contact with underground services	• No traffic controller available to direct construction vehicles and equipment • Operators not trained and no medical fitness certificates available • No PPE provided • No demarcation and warning signages to ensure employees and equipment do not come in contact • No flagman available when equipment is in proximity to excavations

	Activity	RISK	HAZARD/MEASURES
			• Underground services not clearly marked for operators to work safely.
6.	Compactor Operations	Crushing of feet Injuries to hands and arms from prolonged working hours with compaction equipment. Vibration illness	• Employees not trained • Employees not provided with correct PPE for the task at hand.
7.	Concrete Pumping	Sprains and strains Hit by pump Concrete burns Collapse/bursting of structure	• pump operator not trained. • Personnel working with the concrete not wearing the appropriate personal protective equipment to protect against cement burns • Structures overloaded • No support work utilised • Concrete pumping not approved by structural engineer • No supervision during concrete pumping • Machinery in proximity to other materials and excavations.
8.	Confined Spaces	Suffocation Fumes Fatalities	• confined space not sufficiently ventilated • Employees not using masks if air supply insufficient or not of sufficient quality • Oxygen levels not tested • No gas detectors available for employees entering confined spaces. • Employees using safety harness • No life lines attached to safety harness • No rescue equipment such as rescue tripods and BA sets available. • No trained rescuers available onsite • No confined space permits completed • No two way communication with employees working in confined spaces • No spotters monitoring employees in confined spaces
9.	Crusher Operation	Dust Noise Flying particles Contact with machinery/equipment Contact with substance being crushed Crushing injuries Fatalities	• Operators not trained • Employees not using PPE • No dust suppression • Crusher not fitted with guards to prevent unauthorised access. • All access ways not fitted with adequate guard rails to reduce chance of injury from falls from height. • Employees not following procedures when clearing feeder mechanism
10.	Cutting Kerbs	Saw slipping, Blade disintegrating, Noise, and Dust Cutting injuries Amputations	• Employees not following procedure when changing blades • Operator not trained • Operators not wearing the correct PPE • Operators not isolating machinery when "not in use"
11.	Cutting Off Disc	Noise Cuts from machine Fire (particularly at refuelling) Flying debris Blade shattering Contamination by fume created or exhaust fume	• No competent personnel. • Hot works control- No fire extinguisher, No fire watchman. No permit completed • Incorrect PPE utilised • working area with obstructions • Incorrect grade of blade used. • No ventilation • Maintenance not done by a competent person/employee

	Activity	RISK	HAZARD/MEASURES
12.	Demolition	Falling materials Premature collapse of structure	• Method statement not available. • No emergency procedures implemented • structural demolition not approved by the designer and site management • Personnel incompetent • No safe means of access and egress • Employees not wearing correct PPE
13.	Electrical Commissioning	Electric shock	• Personnel not complying with permits to work issued by Client • Personal protective equipment not utilised by employees to prevent electric shock • First aid treatment not readily available • No trained employees for decommission or commission of electrical equipment
14.	Electric Tools and Electrical Installations	Electric shock Fire	• Electric tools and installations not in good condition • electric tools not inspected before use • Do not use electric tools in wet/damp conditions • personal protective equipment such as insulated gloves not utilised • Electrical installations register to be maintained, inspected by competent person
15.	Excavations (Working in and around)	Toxic fumes Collapse of trench walls/trapping Falling into excavation Collapse of adjacent structures	• Deep excavations / monitor air for toxic fumes • Excavations not battered and braced • No Protection for vehicles from falling into excavations – • undermining of other structures (e.g., buildings, scaffolds) • Daily inspections not completed • No safe access/egress in case of emergency. • Excavations formed by explosives with no method statement approved by Client
16.	Explosive Actuated Fastening Devices	Noise Being struck by cartridge or fixing	• Operators not trained and not using correct PPE • Cartridge gun not inspected before use. • Used and unused cartridges incorrectly stored.
17.	Explosive use	Injuries to personnel, passers-by by blast Property damage Fatalities	• Blaster with no permits, permissions, and licences in place before blasting. • Method statement not approved. • No exclusion zone around perimeter of blasting, persons not kept clear, no warning signage and barriers. • No permission from local authority and police. • Blaster not competent in blasting • No pre checks of adjacent structures/buildings before blasting
18.	Fire	Injuries to workers, pedestrians, residents, road users, damage to property through fire	• Site not maintained and no demarcated area for materials that poses a fire risk. • Fire extinguishers not available • No smoking or naked flame near flammable substances or in unauthorised areas signages displayed • No flammable store for Petrol/diesel/flammable substances –
19.	Flammable Liquids and Gases (Use of)	Fire Explosion	• No fire extinguishers available. • No signages displayed • Incorrect use of Petrol/diesel/flammable substances – • Equipment not, maintained

	Activity	RISK	HAZARD/MEASURES
			• Employees not trained for the safe use of flammable substances.
20.	Hand tools	Injuries caused by use of hand tool Impact with the tool Falls due to access problems Contamination with substance being worked	• Employees using damaged or homemade tools • Tools not inspected before use • Safe work procedures not communicated to all employees using handtools • Employees not wearing the required PPE
21.	Hazardous Substances	Injuries to workers through use of hazardous substances, e.g. injuries to eyes, skin, etc.	• Material safety data sheets not available for hazardous substances • No PPE available • No first aid stations available onsite • No handwashing facilities for employees exposed to hazardous substances
22.	Hot Works	Burns to eyes or other parts of the body	• No PPE for task at hand • Respirator maybe be required where cutting galvanized steel or anywhere else toxic fumes and gases arise. Dust can also be a problem and forced ventilation may be required.
23.	Kerb Laying	Nips at joints Crushing by kerbs Caustic burns	• Impervious gloves and barrier cream not available onsite. • Personnel not informed of safe manual handling techniques when handling kerbs.
24.	Lifting Operations	Falling material Crushing by materials Hand injuries to the slinger Toppling crane	• No test certificate • No examination certificate • Pre inspections not completed • No certificates available for lifting equipment (chains, slings, shackles, etc.) • Lifting gear not tagged with safe working load (SWL) • Materials lifted not checked • Crane obstructed by materials and no clear slew path • Lifting area insufficiently barricaded to prevent unauthorised access. No signages displayed. • Banksman not trained • Operator operating crane with expired certificates
25.	Manhole Rings and Pipes Storage	Rolling of rings Collapse of pipes Crushing of persons Stockpile collapse	• Manhole rings not stored flat to prevent them being rolled. • Banks of pipe stockpiles are not to be broken until they are ready for use. • No safe working area provided • Pipes not wedged to prevent rolling
26.	Manual Handling of General Items	Muscular skeletal injuries if the load is too heavy or awkward Operative falling/ tripping Contamination from the substance being carried Fall of material being carried	• Personnel not trained on safe manual handling techniques • Lack of PPE onsite. • Ensure good housekeeping against tripping/fall hazards. • Operative to get assistance if load too heavy- team lift if necessary. • Utilise mechanical lifting and carrying aids where possible. • Personnel to ensure access equipment, ladders will take weight of operative, and load being carried.
27.	Material Hoist	Mechanical failure Overloading Hoist gateway being left open at landings	• Safe working limit not displayed on hoist. • Hoist operator not trained/ competent. • Regular maintenance and inspection of hoist by competent person not completed • No Records of maintenance and inspection • Hoist gate should be fitted with mechanical and electrical interlocking devices.

	Activity	RISK	HAZARD/MEASURES
28.	Members of Public – Protection of	Injury to member of public and road users from site works	• Barriers and signage not place • Workers must warn away any members of public from the works • Footpaths and bridges which are open to public must be closed off if in area of works or otherwise made safe so that no injury occurs to members of public • Traffic turning into site – traffic management and signage as required. • No Signage on road at site entrance warning motorists that construction traffic turning into/out of site access. • plant risk assessment not updated for plant safety precautions • NOTE: SIGNAGE TO BE POSTED ON SITE TO WARN OF CONSTRUCTION TRAFFIC MOVEMENTS. SAFE MEANS OF ACCESS FOR BOTH CONSTRUCTION TRAFFIC TO SITE AND PRIVATE HOMEOWNERS MUST BE AGREED.
29.	Mobile Crane Erection and Dismantling and Use	Collapse of structure Overturning of structure Falling materials	• Ensure emergency procedures are in place and all operatives are aware of the details • Only use trained and competent operators for the erection and dismantling and use of cranes • Ensure crane driver is trained and holds certification as proof. Must have valid medical certificate of fitness. • Ensure there is safe means of access available at all times • Ensure the mobile crane driver has 360° vision if not ensure a fully trained banksman is used • Banksman to wear reflector vest to identify himself to the crane driver • Ensure all personnel wear suitable and sufficient personal protective equipment • Consider creating exclusion areas
30.	Night Work	Security Lighting	• The Contractor shall not undertake any night work without prior arrangement and a written permit from the Client. • The Contractor shall ensure that adequate lighting is provided for all night work and failure to do so shall result in work being stopped.
31.	Noise and Dust	Breathing in dust can cause long term health problems, noise can damage hearing	• Wear respiratory and hearing protection • Dampen down and minimise dust where possible.
32.	Overhead Services (Working near)	Contact with live services causing injury to personnel Damage caused to services	• Maintain safe clearance levels • Establish presence of any services via proper walk-through survey of site and/or means of service drawings • Wear personal protective clothing • Ensure height of plant/vehicles does not compromise or exceed clearance levels for overhead services • Obtain information on clearance levels from service provider
33.	Painting	Contact with paint	• Refer to safety data sheet for usage instructions, hazards and precautions required. • When working at height, refer to risk assessment.
34.	Paving (Laying)	Impact injuries from tile / mallet Caustic burns Sore knees Cuts from cutter	• Impervious gloves to be worn/ barrier cream to be used • Kneelers or similar to be available • Personal protective equipment to be worn – for example if saw used to cut pavers

	Activity	RISK	HAZARD/MEASURES
35.	Plant or Vehicles and Equipment Operation	Workers injured by passing traffic Road users and pedestrians at risk from plant operation Noise	• Implement traffic protection measures • Trained and competent operators must be used • Check plant and vehicles on daily basis before use and record inspections. Maintain vehicles in safe condition. • Medical certificates of fitness required for construction plant. • Crossing of road by construction vehicles or machines must be limited to the practical minimum • Plant and vehicles must be fitted with amber rotating beacons and reverse alarms. • Wear appropriate protective clothing/equipment, e.g., goggles, gloves, ear defenders, etc. as appropriate.
36.	Plastering	Falling materials Fall from height Contact with materials	• standard safety procedures are not followed • No safe working area provided • No safe access and egress • competent personnel are not used
37.	Plumbing	Falling material Falling from height Fire Burns Exposure to lead fumes	• standard safety procedures are not followed at all times • Only used trained and competent personnel • safe working area not provided • materials incorrectly stored • PPE not utilised • No hot works permit system prior to commencing any hot works • Make sure emergency procedures are in place and ensure all personnel are aware of where to go in case of a fire
38.	Precast Slab / Unit Laying and Fixing	Falls Falling materials Manual Handling	• Emergency procedures in place and personnel explained details • Use competent personnel • insufficient access and egress provided • Safe place of work must be provided • personnel not wearing correct personal protective equipment • Exclusion zone may be required for protection against risk of falling objects
39.	Working next to Railway line/in Railway reserve	Risk of being struck by train Damage to track or Railway property by works	• Specific advice to be sought from safety advisor
40.	Road Construction	Risk of being struck by vehicles	• No traffic management measures in place • No construction activities to commence until adequate provision made to accommodate traffic in accordance with the South African Traffic Signs Manual. • Wear reflective waistcoats when working on or near the road or road shoulder as well as any other required personal protective clothing. • Crossing of road by personnel must be limited to the practical minimum • Use of fencing or other barriers as appropriate
41.	Road Marking	Contact with moving vehicles Fire	• Ensure suitable and sufficient road signs are erected, as applicable • Possible road or lane closure may be required – traffic management may be required

	Activity	RISK	HAZARD/MEASURES
			• Fire Extinguisher to be situated in a suitable area, use dry powder or foam
42.	Road Working – working in or next to road	Injury to workers caused by passing traffic Injury to road users and pedestrians by works	• Flagmen to be used where interface with construction plant with passers-by or where hazard posed by delivery vehicles turning into/out of site. • Traffic management plan to be approved by Municipality and, if necessary, traffic department • No construction activities to commence until adequate provision made to accommodate traffic in accordance with the South African Traffic Signs Manual. • Use safety signage to warn traffic and pedestrians of construction works • Where existing walkways/pavements affected by works, must direct pedestrian traffic away to safe walking area. • Wear reflective waistcoats when working on or near the road or road shoulder as well as any other required personal protective clothing. • Crossing of road by personnel must be limited to the practical minimum • Use of fencing or other barriers as appropriate
43.	Scaffold Erection/ Dismantling	Personnel falling from a height Items of scaffold falling onto personnel Scaffold collapsing onto those below	• Contractor not ensuring: • scaffold is designed to take the imposed loads • scaffolding is constructed properly • scaffold is not overloaded • scaffolders are fully trained • scaffolding is regularly checked by competent person and record of inspection retained. Written inspections to be recorded on weekly basis • scaffolders must adhere to the safe systems of work. • all fall arrest equipment to be checked and certified in good working order • that ALL understand the safe system of work
44.	Shuttering Walls, Beams, Columns	Falling from height Falling materials from height Cuts and abrasions from splinters and nails	• Ensure all personnel wear the appropriate Personal Protective Equipment • Ensure at all times there is a safe working platform • Use only trained and competent personnel • If electrical tools are being used ensure they have been tested and safe to use • Ensure timber is de-nailed after use • Ensure safety standards are followed at all times • Ensure there is a safe means of access and egress at all times
45.	Site Strip	Overturning Vehicles Collisions Damage to property Fatalities	• Follow standard safety procedures • Only use trained and competent personnel • Ensure there is a suitable and safe means of access and egress • Ensure banksman used when required • Ensure all personnel wear suitable reflector vests as required
46.	Snakes	Snake bite Fatalities	• Qualified first aider required for site who can treat snakebite • Snake bite kit to be on hand

	Activity	RISK	HAZARD/MEASURES
			• Check area before working • Find out nearest hospital and get emergency telephone numbers.
47.	Steel Erection	Falls from height Falling components Contact injuries from falling lifting equipment	• Adhere to all general precautions for working at height • Barrier off / exclude area below work • All lifting appliances to be examined and inspected • Inspection register in place and up to date • All personnel to be trained and competent and wear clipped on safety harnessed when working at height • Ensure that lifting equipment (slings, chains, shackles) test certificates are current and on site. • Competent persons only to connect loads and direct plant
48.	Steel Fixing	Back injuries caused by manual handling Eye injuries from tie wire Trips / falls Falling form height	• PPE must include safety boots and goggles • Manual handling training may be required • Care to be taken when working near overhead lines • Use only trained personnel • Provide safe means of access • Maintain and regularly inspect all lifting appliances and equipment • Cap starter bars to prevent injuries where feasible • Construct scaffold walkways to cross reinforcing mesh, as required
49.	Street Lighting / High Mast Security Lighting	Contact with vehicles Electrical Shock Collapse of columns	• Ensure competent personnel are used • Area to be kept clear – keep unauthorised persons away • Plant and lifting equipment to be maintained as per risk assessments above • Electrical connections to be done by qualified personnel only
50.	Temporary Works – shoring, scaffold, falsework, formwork	Collapse of form work	• Wear personal protective equipment such as gloves and goggles • Formwork must be built by trained person and also be inspected by competent person and results entered into register on site
51.	Tower (Mobile Aluminium Tower) Scaffold	Overturning Falls	• Tower to be on firm level ground with wheels or feet properly supported. • Erection by competent person • Inspection before first use • Weekly record of inspection required • Guard rails and Toe boards • Overhead obstructions, such as power lines • Never move in strong winds
52.	Troxler – use of	Radiation exposure Transportation and storage of nuclear equipment Working in road	Contractor not ensuring: • Training of Troxler gauge operators in basic radiation safety and correct operating procedure to satisfactory level of competence • An enclosed vehicle must be used for transport of the gauge • After use and before storing the gauge, a visual check to be carried out to confirm shutter is properly closed • Warning signage to be displayed at entrance to store indicating presence of radioactive material

	Activity	RISK	HAZARD/MEASURES
			• Wear reflective vests when working in or near the road or road shoulder as well as any other required personal protective clothing.
53.	Underground Services	Striking of buried services Electrocution Collapse of underground pipes Serious injuries that will result in hospitalisation	• Contractor not making all necessary enquiries to establish what services are in the area. Consult drawings and advice from service provider (e.g., Municipality or ESKOM) when planning work. • Assume all service to be live (Unless confirmation is received to confirm that services are isolated or otherwise made safe). Do not work near live services without authorisation from site management. • Comply with the requirements of the safe system of work for underground services. • Where available, locate services with a locator • Hand dig around services
54.	Working at Height	Personnel falling form height Falling debris Those beneath being injured Head injuries	• All access equipment is properly constructed (inspections record must be maintained) • Only trained personnel construct, dismantle or control the access equipment • All access equipment must have full toe boards and guardrails - comply with SANS 10085 on erection, use and dismantling of scaffolding • No access equipment may be loaded above the level of the guardrail • No access equipment to be loaded above its safe working load • Where work involves leaning out on an open leading edge, then all personnel are to be fitted with full body harness. The harness must be connected at all times • All fall arrest equipment to be correctly maintained • Ensure if ladders are being used for access, they are either footed or tied. Also, the ladder must be set at the correct level of 1 in 4 or approximately 75°
55.	Work over or next to Water	Drowning	• Evaluate depth of water, height above water that work takes place, whether workers can swim or not and then determine safety precautions required: these may include such measures such as barriers, signage, life belts, safety harnesses, etc. • When working on river/harbour/dam edge - erect life saving devices and barriers to protect workers and vehicles (stop blocks may also be required). Only trained and competent persons to be used.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 4

ENVIRONMENTAL MANAGEMENT

TCTA MODULAR STANDARDS
SECTION 4
ENVIRONMENTAL MANAGEMENT

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SECTION 4
ENVIRONMENTAL MANAGEMENT (NATURAL AND SOCIAL)

4.1 SCOPE

This Section covers the requirements for controlling the impact of construction activities on the environment relating to both the biophysical and social environment.

The Contractor shall take full responsibility for protecting the environment and eliminating or minimising the negative impacts of construction on the environment. The Contractor shall prevent or limit the occurrence of incidents which may cause damage to the environment, and mitigate the consequences of such incidents. Nothing specified herein shall relieve the Contractor of any obligations or responsibilities in this regard.

The Contractor shall be aware of the importance of maintaining appropriate relationships with the landowners on whose properties he will be operating, as well as any tenants or occupiers of such properties. The Contractor and his workforce must ensure that their actions in no way damage the relationship between the landowners, tenants and occupiers, and the Employer. The Contractor shall prevent or limit the occurrence of work-related accidents that may cause damage to the landowner/tenant/occupier relationships, as well as their social environment, and prevent or relieve the consequences of such accidents.

4.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

4.2.1 Definitions

a) **“Community**” means a social unit with commonalities such as norms, religion, values, customs, traditions, or identity. Communities may share a geographical area or a virtual space through communication and interactive platforms. Durable relations that extend beyond immediate genealogical ties also define a sense of community. It is important to their identity, practice, and roles in social institutions such as family, home, work, government, society, or humanity at large. Although communities are usually small relative to personal social ties, "community" may also refer to large group affiliations such as national communities, international communities, and virtual communities.”

b) “**Contaminated water**” means water contaminated by the Contractor's activities, e.g. concrete water and all runoff from wash areas.

c) “**Environment**” means the surroundings within which humans exist and that are made up of:

   i) The land, water and atmosphere of the earth;
   ii) Micro-organisms, plant and animal life;
   iii) Any part or combination of i) and ii) and the interrelationships among and between them; and
   iv) The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

d) "**Environmental incident**" means events (accidental or due to non-compliance with specification) that are either natural (e.g. fires, floods etc.) or human induced (e.g. oil, diesel or hazardous liquid spill) or related to labour issues (strike action etc.) that may cause a significant negative or social impact, or that may result in public concern.

e) **"Fertile Soil"** means at least 500 mm (in cultivated land) and 450 mm (in all other areas) of the profile of soil still present after the "Topsoil" (i.e. OGL minus 300 mm and 150 mm respectively) had been removed or the actual depth of fertile soil available if it is less than these specified values, which will also be regarded as maximum values or as determined during the pre-construction survey.

f) "**Flood plain**" means the area located on either side of a watercourse that is below the 1:100 year flood line.

g) "**Hazardous substances**" means any substance defined or listed in the Regulations for Hazardous Substances. For the purpose of this Contract, hazardous substances shall include all compounds that pose a risk of contaminating water and soil, or exerting a deleterious effect on any living organism, and including but not limited to petrol, diesel, engine oil, hydraulic oil, shutter oil, curing compound, paint and epoxy products.

h) "**Existing vegetation**" means all existing species, indigenous or otherwise, of trees, shrubs, groundcover, grasses and all other plants found growing on the site.

i) **"Local"** means inside the borders of South Africa, however with regard to employment and all other economic opportunities pertaining to the project preference is given to the targeted geographical area within the Swartland Local Municipality and Boland Local Municipality.

j) "**OGL**": Original ground level as surveyed prior to any activities taking place. "**Oil separator**" means a trap that separates oil from water and prevents oil from being carried from the Works area.

k) "**Pollution incident**" means any incident that results in the release of a substance or substances that causes pollution and associated damage to the natural environment.

l) "**Potentially hazardous substance**" is a substance that, in the reasonable opinion of the Engineer, can have a deleterious effect on the environment.

m) "**Reasonable**", unless the context indicates otherwise, means reasonable in the opinion of the Engineer after he has consulted with a person suitably experienced in environmental management practices.

n) "**Sensitive area**" means any area that is denoted as sensitive by the specifications or Engineer, due to its particular attributes (refer to Annexure 4/1). These attributes could, for example, include the presence of rare or endangered vegetation, the presence of heritage resources (e.g. archaeological artefacts or graves), the presence of a unique natural features, the presence of a watercourse or waterbody, etc.

o) **"Social Management"** refers the projects Social Performance. Social Management will be informed by the project localities socio-economic conditions, and other external impact factors.

p) "**Solid waste**" means all solid waste, including construction debris, excess cement/concrete, wrapping materials, timber, tins and cans, drums, wire, nails, food and domestic waste (e.g. plastic packets and wrappers).

q) **"Stakeholders"** means any entity/persons who is affected by the Employer's operations in the Local Area(s) and/or who has an interest or concern in project, either as a decision maker, participant or affected party and may include, amongst others, delegated representatives from the District Municipality and Local Municipalities, communities and entities involved in construction including Subcontractors

r) **"Target Area"** means the geographic area defined in the Contract Data for Targeted Enterprise and Labour and which typically are:

i) One or more Provinces;
ii) One or more Metropolitan or District Municipalities;
iii) One or more Local Municipalities;
iv) One or more Wards that are predominantly located within an area and within a predefined radius of the construction activity; and
v) One or more of the areas listed in the definition of the Designated Groups.

s) **"Topsoil"** means at least the top 300 mm (in cultivated lands) and 150 mm (in all other areas) of the soil profile irrespective of the fertility appearance, structure, agricultural potential, fertility and composition of the soil or the actual available depth if it is less than these specified values, which will also be regarded as maximum values or as determined during the pre-construction survey.

t) "**Watercourse**" means:

i) a river or spring;
ii) a natural channel in which water flows regularly or intermittently;
iii) a wetland, lake or dam into which, or from which, water flows; and
iv) any collection of water which the Minister of the Department of Water and Sanitation may, by notice in the Gazette, declare to be a watercourse and a reference to a watercourse includes, where relevant, its bed and banks.
(i) any river, stream and natural drainage channel whether carrying water or not.

u) "**Waterbody**" means a local topographic depression that contains any form of water and includes dams and wetlands, whether these are ephemeral or permanent.

v) "**Wetland**" means all areas with waterlogged soils, or soils covered with a shallow layer of water (permanently or seasonally), unique types of soil formed under seasonal or permanent saturation and with distinctive plants adapted to water-saturated soils.

4.2.2 Abbreviations

CDP: Community Development Projects
DFFE: Department of Forestry, Fisheries and Environment
EA: Environmental Authorisation
ECO: Environmental Control Officer
EM: Environmental Monitor
EO: Environmental Officer

EMPr: Environmental Management Programme
MMS: Management Method Statement
NEMA: National Environmental Management Act
SHEQ: Safety Health Environment and Quality
SAPS: South African Police Service
TCTA: Trans-Caledon Tunnel Authority

4.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

4.3 ENVIRONMENTAL MANAGEMENT

4.3.1 Legal and General Obligations

All construction activities shall observe and obey any relevant environmental legislation and shall be undertaken in such a manner to minimise impacts on the surrounding environment, the public and adjoining landowners in line with the objectives and targets specified in the approved Environmental Management Programme (EMPr).

The Contractor shall construct and/or implement all the necessary environmental protection measures in each area before any construction work will be allowed to proceed.

The Employer is required to:

- Apply for Environmental Authorisation (EA) from the Department of Forestry, Fisheries and Environment (DFFE), in terms of the National Environmental Management Act (NEMA) and its associated Environmental Impact Assessment (EIA) Regulations, for the construction and operation of the proposed project (already applied for and granted).
- Seek approval from the Department of Mineral Resources (DMR) in terms of the NEMA and the Mineral and Petroleum Resources Development Act (MPRDA) for all required borrow pits.

The Contractor is required to:

- Apply for permit(s) from DFFE, in terms of the National Forestry Act (NFA), for the cutting, disturbance, damage, destruction or removal of trees in a forest, or Protected Trees.

- Apply for permit(s) from the Provincial Department of Environmental Affairs and Development Planning (DEADP), in accordance with Nature and Environmental Conservation Ordinance (No. 19 of 1974), for the removal of protected plants.
- Seek permit(s) from the Provincial DEADP, in terms of the NEMA and National Environmental Management Biodiversity Act (NEMBA) for the removal and transportation of endangered fauna and flora.
- Seek permit(s) from South African Heritage Resources Agency (SAHRA) if heritage resources are to be impacted on (relocated or destroyed), and for the removal of graves.
- Seek Water Use Authorisation from the Department of Human Settlements Water and Sanitation (DHSWS) for construction-related water uses in terms of Section 21 of the National Water Act (NWA).

Approvals are to be in place prior to the potential impacts to the protected environmental features.

4.3.2 Method Statements

The Contractor shall include environmental management as part of the relevant method statements for the construction of the Works, covering those activities which are identified as being potentially harmful to the environment.

The method statements shall include a risk assessment identifying all environmental hazards associated with the activity and commentary on environmental control measures required to prevent problems (or at least limit their effects). The Contractor shall further include for evaluation, his elaborate and fully detailed methods for the maintenance, adherence, and protocols for all six primary elements of Social Management related approaches. Part of/ all of certain aspects may have been addressed in other requirements, and for those the Contractor shall refer to the relevant method statement.

The method statements required to assist in the implementation of this EMPr include at least the following:

a) Site clearing;
b) Establishing the construction camp(s);
c) Waste and wastewater management;
d) Drainage and stormwater layout and control methods;
e) Erosion control and prevention of sediment deposition;
f) Dewatering;
g) Water quality monitoring,
h) River and stream crossings;
i) Procedures for dealing with possible emergencies that can occur, such as fire and accidental leaks and spillage of carbon fuels and oils;
j) Dust control;
k) Storage and handling of hazardous substances;

l) Management of concrete and batching plants;
m) Sourcing, transport and storage of materials;
n) River diversions and working in watercourses;
o) Managing spoil material;
p) Controlling alien invasive species and noxious weeds;
q) Decommissioning of the construction works area;
r) Rehabilitation of the construction footprint; and
s) Other required by the Engineer.

The method statements must be project- and site specific and should explain in detail at least the following:

a) The manner in which the work is to be undertaken;
b) The estimated schedule for the works (timing);
c) The area where the works will be executed (location);
d) The materials and plant / equipment needed for the works;
e) The necessary mitigation measures that need to be implemented to adequately safeguard the environment, construction workers and the public (where applicable);
f) Training of employees;
g) Roles and responsibilities; and
h) Monitoring and reporting requirements.

4.3.3 Key Resources

4.3.3.1 Environmental Control Officer (ECO)

As a result of the statutory authorisation process in terms of the existing South African environmental legislation, an independent Environmental Control Officer (ECO) shall be appointed by the Employer to audit and confirm all environmental compliance.

The ECO shall conduct monthly inspections and an audit within 30 days of completion of construction, with a final audit within 30 days of completion of rehabilitation. The ECO's inspection reports shall be made available to the Contractor for response and remedial action.

The role of the ECO is primarily to act as an independent monitor on behalf of the DFFE for the implementation of the project, in accordance with the requirements of the EA and the approved EMPr.

The role and function of the ECO is to:

a) Conduct independent, third-party monitoring and auditing;
b) Regularly monitor and review the progress towards achieving the specific strategies, objectives and performance targets of the EMPr;

c) Independently verify that mitigation measures and conditions in the EMPr are being applied;
d) Conduct regular site inspections and issue inspection reports;
e) Review monitoring data and evaluate against performance targets;
f) Provide independent reporting to DFFE on compliance with the EA and EMPr; and
g) After consultation with the Employer, inform decision-making authorities when there is non-compliance with conditions of approval.

As an independent Consultant, the ECO is not responsible for:

- EMPr implementation or enforcement.
- Primary environmental data collection, monitoring and analysis; and
- Resolving complaints from Interested and Affected Parties (IAPs).

The ECO is not accountable for the implementation of the EA and the EMPr and is also not linked to the project authorities, the Engineer or the Contractor. Therefore, the ECO does not have the authority to:

- Make project-related decisions;
- Issue instructions to either the Engineer or the Contractor;
- Stop the construction works; and
- Demand the implementation of specific mitigation and/or corrective measures to the Engineer or Contractor.

4.3.3.2 Environmental Monitor (EM)

The Engineer shall appoint one designated member of his staff as the Environmental Monitor (EM), who shall be tasked with monitoring compliance by the Contractor and his staff with the environmental and social requirements of this Standard, the site-specific approved Environmental Management Programme (EMPr) and the Environmental Authorisation (EA) for the duration of the project.

The EM (Engineer's representative) will contribute to /participate in the following:

- Compilation of a monthly report to the Engineer detailing environmental compliance, audit summaries and incidents;
- Monitor complaints related to the physical and social environment received from the public;
- Monitor the rectification of any pollution, contamination or damage to the project site, rights of way or adjacent land;
- Attend monthly SHEQ committee meetings with ECO, Resident Engineer, SHEQ Auditor etc.;
- Consolidate info for monthly reports to the Employer; and
- Attend monthly meetings with Contractor, Engineer and Employer.

4.3.3.3 Environmental Officer (EO)

The Environmental Officer (EO) shall be part of the Contractor's Personnel and is responsible for all activities related to the day-to-day on-site implementation of the EMPr and compliance with the environmental requirements. The EO is also responsible for the compilation of regular (daily, weekly and monthly) Monitoring Reports.

The EO must liaise with the Engineer on all environmental and related issues (when necessary) and ensure that any complaints received from the public are recorded and dealt with appropriately and expeditiously. The Contractor must ensure that all his/her employees, visitors and Subcontractors receive Environmental Awareness Training as specified.

The EO shall:

a) Be well versed in environmental and social matters;
b) Understand the relevant environmental legislation, international best practices and processes;
c) Understand the hierarchy of environmental compliance reporting, and the implications of non-compliance;
d) Be able to resolve conflicts and make recommendations to the Contractor in terms of the requirements of the EMPr;
e) Keep accurate and detailed records of all EMPr-related activities on site;
f) Keep the following on file:
    - Safety Data Sheets (SDSs) for all hazardous material stores;
    - Waste related records and disposal certificates; and
    - Training registers.
g) Arrange the presentation of environmental awareness training courses/toolbox talks to all visitors, site staff, Contractors and Subcontractors, and monitor the environmental awareness training for all Contractor's Personnel; and
h) Advise on the rectification of any pollution, contamination or damage to the project site, rights of way and adjacent land.

The EO shall be responsible for:

a) Aiding the Contractor to comply with all the project environmental requirements, objectives and targets;
b) Facilitating environmental activities and environmental awareness training of all personnel on site, and
c) Implementing an internal environmental compliance management system.

The EO will contribute to / participate in the following:

- Weekly environmental toolbox talks;
- Weekly reports and monthly reports to be submitted to the Engineer;
- Environmental monitoring;

- Weekly report to the EM; and
- Attend monthly SHEQ committee meetings with ECO, SHEQ Auditor, etc.

The EO shall be supported with other staff as required to fulfil all these requirements.

4.3.3.4 Water Quality Specialist

The Water Quality Specialist is part of the Contractor's Personnel and is responsible for baseline water quality measurement and the monitoring of construction phase water quality, primarily to monitor the physical, chemical and biological characteristics of water, the quantitative flow regime, as well as the quality of the instream and riparian habitats to ensure that they are not adversely affected by the development.

4.3.3.5 Air Quality Specialist

The Air Quality Specialist is part of the Contractor's Personnel and is responsible for baseline air quality measurement and monitoring of construction phase air quality parameters, primarily for the control of dust.

4.3.3.6 Noise Specialist

The Noise Specialist is part of the Contractor's Personnel and is responsible to undertake a baseline noise survey of the site prior to commencement of site activities in accordance with the requirements of the Noise Induced Hearing Loss Regulations (OHSAct 85 of 1993) and SANS 10083:2004.

4.3.3.7 Ecological Specialist

The Ecological Specialist (with wetland and rehabilitation experience) is part of the Contractor's Personnel and must produce an ecological report to provide a pre-construction baseline description of the habitats and vegetation types on the construction site. The report must include maps and photographic records per directly affected property and describe the vegetation types as well as:

- Mitigation for threatened/protected species of conservation importance;
- The alien invasive plant species and weeds that will need to be controlled and the methods of control;
- Detailed and specific rehabilitation requirements – fertilisers, seed mixes, timing, maintenance, type of applications, etc.;
- Baseline studies/monitoring where required should be undertaken prior construction in order to provide a benchmark against which impacts resulting from the development; and
- Determine the depth of the topsoil and fertile soil.

Furthermore, a walk-through of the final pipeline route must be conducted prior to construction in late winter / early spring by a qualified botanist who is highly familiar with vegetation of the region.

Should Species of Conservation Concern be encountered, they must be avoided and only if this is completely impossible, then search and rescue must be undertaken by a qualified botanist or horticulturalist.

A permit must be obtained from the relevant nature conservation agency for the removal or destruction of any indigenous protected and endangered plant and animal species, if required.

Prior to construction, animal species of conservation importance (such as the Geometric Tortoise and Blue Crane) must be rescued and relocated. An experienced person, who is highly familiar with the fauna of the region must identify the possible Red Data fauna on the site and acquire the necessary permits to relocate fauna if avoidance is not possible.

4.3.4 Environmental File

4.3.4.1 Documentation

Documentation that must be included in the site Environmental File shall include as a minimum:

- Environmental Authorisation (including all amendments thereto);
- EMPr;
- Method statements (procedures) for environmental requirements; and
- Register and proformas for records as indicated below.

This documentation shall ensure the effective planning, operation and control of environmental requirements.

4.3.4.2 Records and Record Keeping

Record keeping is to be agreed with the Engineer and shall ensure the effective planning, operation and control of processes that relate to environmental aspects.

The EO will be responsible for maintaining all records in relation to the EMPr requirements on site. Such records will be made available to the Engineer during any audits, as well as at any time as requested by officials of the DFFE and/or the Employer. Typically, these records will include:

a) Daily Environmental Management Reports / Checklists;
b) Monthly summaries of daily reports;
c) Incident and non-conformance reports as well as an Incidents Register; Environmental awareness training records;
d) Waste management records;
e) Servitude management records (e.g. erosion control, weed control);
f) Sensitive areas records (e.g. wetlands, fauna and flora, heritage sites);
g) Monitoring schedule;
h) Monitoring databases (e.g. water quality, air quality, noise, ecology);

i) Internal and external audits;
j) Spill clear up records;
k) Register of hazardous substances;
l) Water use records – construction water;
m) Waste transfer notes (including hazardous waste);
n) Method Statement Register;
o) Public Complaints / Grievance Register
p) Compliments Register; and
q) List of “toolbox talks” topics.

Copies of the following are to be kept on file with the Contractor for reference as required:
a) EA and EMPr;
b) Waste transfer notes;
c) Subcontractor environmental performance records;
d) Training Records;
e) Environmental Induction records;
f) Visitors Induction and Indemnity records;
g) Environmental Officer Letter of Appointment;
h) Material Safety Data Sheets for all hazardous substances; and
i) Internal compliance monitoring records (e.g. Corrective Action Reports, Non Conformance Reports).

4.3.4.3 Reporting

(a) Daily Environmental Reports

Daily environmental reports are to be compiled and copied to the Engineer for information within one working day. These reports must be designed to facilitate communication, problem solving, flow of information and cooperation between the Engineer and Contractor with regard to environmental and social matters.

(b) Monthly Reports

The environmental and social management compliance shall be included in the project’s monthly progress reports.

(c) Incident and Non-conformance Reports

The Contractor shall establish procedures for the reporting of environmental infringements, improvements to practice, non-conformances and incidents. The Contractor shall act on these reports as soon as reasonably practical. The Contractor shall ensure that these reporting procedures are complied with by all Subcontractors on the Site. All incidents shall be investigated and the results of all investigations are to be assessed with a view to continually improve performance.

The Contractor shall submit to the Engineer at the end of each month, reports and statistics on all environmental incidents, infringements, and improvements.

4.3.5 External, Independent Compliance Monitoring

Compliance to the environmental management requirements shall be monitored and reported on through ongoing site inspections, monitoring and evaluation of performance against targets. Compliance monitoring will be undertaken by the ECO.

It is anticipated that the ECO will undertake monthly inspections and an audit within 30 days of completion of construction, with a final audit within 30 days of completion of rehabilitation.

Compliance monitoring will commence in the pre-construction phase, where those conditions in the Environmental Authorisation (EA) that need to be adhered to prior to project implementation will need to be checked and recorded, as well as to check compliance with the provisions in the EMPr.

The Contractor shall attend the initial (start-up) audit that will be undertaken by the ECO prior to the commencement of construction. The audit will include a site visit and a qualitative survey of the status of the area.

Compliance monitoring during construction will include an audit of site activities as well as the content of the Environmental File and all reports compiled by the Contractor's Environmental Officer (EO).

The Contractor shall provide to the ECO all relevant monitoring data, which shall include but shall not be limited to water, air quality, noise, ecological and traffic monitoring, complaints and pollution incidents and non-conformances within two days after the request has been received.

The Contractor shall ensure that his EO attends all site inspections arranged by the ECO and provide all relevant information requested during and within 24 hours after the site inspection.

Compliance monitoring will be completed at the end of the Defects Notification Period to check the effectiveness of rehabilitation measures and whether the related objectives have been met.

4.3.6 Internal Auditing

Internal environmental audits shall be carried out by the Contractor's 0EO on a quarterly basis. Audits shall focus on compliance with:

- Environmental management processes and documentation (including the EA, EMPr and method statements);
- Environmental requirements; and
- Legal compliance.

The audit reports shall detail corrective and preventive actions for findings.

The Contractor shall submit copies of audit reports to the Engineer and the ECO.

4.3.7 Incident Preparedness and Reporting

The Contractor shall prepare and submit to the Engineer an Environmental Emergency Response Method Statement. This response plan will further cover unplanned or unexpected disruptions that arise from disruptive business behaviour so that construction can resume as quickly as possible. A list of persons and organisations including addresses and phone numbers (Suppliers, Contractor, Employer, local authorities, fire brigade, and hospitals) shall be established and made readily available for emergency environmental incident response.

Frequency of emergency response exercises shall be jointly determined with the Engineer and shall be outlined in the Environment Emergency Response Method Statement.

The Environment Emergency Response Method Statement shall address the eventuality and measures to be implemented in case of a major environmental incident, including adequate external communication. This document shall detail the following:

- Description of the environmental incident levels and degrees of required response depending on the severity of the incident;
- Distribution and issuing of spill response equipment by crews and facilities and procedures for intervention, depending on the level of environmental incident;
- Frequency and objectives of emergency response exercises;
- Scope of emergency response team, list of persons and organizations including addresses and phone numbers for emergency environmental incidents response; and
- Communication flowchart in case of environmental emergency.

The objective of the emergency response is to minimise the harmful effects of any incident on the environment.

Once emergency actions have been carried out, the normal corrective and preventive actions shall be undertaken by the Contractor.

The Contractor will be required to provide contingency plans for situations where the failure of an environmental management process could result in significant pollution problems. It is preferable to have planned for contingency beforehand, rather than to wait for the failure and a pollution incident to occur.

The Contractor will be required to have available equipment and materials to be able to deal rapidly with the more serious pollution incidents, in particular:

- Fuel or chemical spillage;
- Watercourse pollution (e.g. by oil); and
- Fire.

Environmental incidents and accidents are unforeseen / unplanned events that may lead to the loss of life, injury and/or property damage, with incidents considered to be preventable while accidents are not.

An initial report of an environmental incident / accident must be submitted to the Engineer within 24 hours of occurrence and an investigation report must be submitted to the Engineer and the authorities in line with legislation (S30 of NEMA and S20 of NWA) within 48 hours of occurrence in a format agreed upon with the Engineer. Each environmental incident report must contain as a minimum, a description of the incident, a statement on the severity and significance of the impact, and actions taken to remediate the resultant damage. A similar approach is required by the Contractor when reporting on an accident.

Environmental incidents and accidents constitute all those activities and events that may have a negative impact on the surrounding natural and social environment. An incident is an unplanned, undesired event that hinders completion of a task and may cause injury, illness, or property damage or some combination of all three in varying degrees from minor to catastrophic. It is generally preventable and an event that can be planned for. While the definition of an accident is like that of an incident, it is an event that could not be planned for.

4.3.8 Site Meetings

Environmental and social management performance and compliance with the environmental and social requirements will be an item on the agenda of the monthly site meetings. In addition, the Contractor shall attend a monthly coordination meeting for all the environmental role players on the project. A seven-day SM activity report shall be formally transmitted to the Engineer on a weekly basis. These reports will be designed to facilitate communication, problem solving, flow of information and cooperation between the Engineer and Contractor with regard to SM matters.

4.3.8.1 General

If criteria within the EMPr are not fulfilled and corrective action is not taken, an environmental non-conformance may be raised by the EM through the Engineer and a non-conformance notice issued.

Examples of circumstances where this may arise include:

- Receipt of a complaint regarding pollution or other environmental impacts caused by the project;

- Departure from approved or agreed procedures; and
- Non-conformance identified because of any self-assessment, formal audit or other environmental survey or inspection.

4.3.8.2 Corrective Action

Corrective action may include changes to work instructions (frequency of testing, test method etc.), alterations to a method statement or other procedure, further staff training, etc. Non-conformances will be reviewed by the EM and will be discussed in construction meetings as relevant.

An environmental non-conformance / corrective action report can be issued to the Contractor by the Engineer. It is the responsibility of the Contractor to immediately initiate corrective actions and, once completed, provide details of the actions undertaken on the non-conformance / corrective action report and return it signed to the Consultant's EO within an agreed timeframe. If the non-conformance is considered to breach legislative requirements, the breach must be reported to the relevant authority and the Employer.

4.4 SOCIAL MANAGEMENT

4.4.1 Social Management Principles

The Contractor shall at all times ensure that the following principles of Social Management are adhered to:

- Build positive and productive relationships with stakeholders as a way of promoting social cohesion and partnerships;
- Mitigate the adverse impacts of the project on landowners and land users, thus reducing social risks on the project;
- Operate in a manner that is inclusive and caters to systemically vulnerable groups through the establishment of platforms that allow for ease of engagement in relation to the locality's social fabric;
- Endorse informed consultation and participation by involving multiple sectors of society such as business forums, women and youth groups, education forums, farmer associations and those impacted by the project in community engagements;
- Promote transparent and accountable governance by establishing and facilitating project institutional structures through forums and platforms for communication and feedback with stakeholders;
- Transport labor and equipment in a safe and acceptable manner and over routes provided for access to the site. Work shall be performed in a manner that prevents damage to crops or property; and
- In general, human rights protocols through due diligence processes of all people shall be considered important/primary to the project and interacted with in the utmost respectful manner.

4.4.2 Social Management Objectives

The Contractor shall at all times ensure that the following objectives of Social Management are adhered to, and thus:

- Actively mitigate social issues that may impact on the project's production.
- Manage and minimize risks that may impact on social management outcomes.
- Update and maintain the TCTA developed database of project stakeholders (including interested parties and stakeholder sectors), their contact details, and all interactions and transactions that take place with them.
- Identify and maximise potential project opportunities for the social benefit of stakeholders.
- Facilitate the implementation of mitigation measures by ensuring that all project-affected persons are informed of the project, its objectives and associated activities, and how these may affect them.
- Monitor and evaluate parameters to ensure implementation of social risk mitigation measures.
- Ensure that mitigation measures are effective.
- Ensure that livelihoods of project-affected persons are protected/ enhanced.

The six (6) functional areas of social management require specific approaches and interventions which are aligned and managed in support of each other. TCTA's Social Management programme is therefore divided into six primary elements of social management and their significant activities:

- Interdisciplinary Collaboration.
- Stakeholder Engagement.
- Socio-Economic Transformation.
- Community Development Projects.
- Resettlement and Livelihood Restoration.
- Social Monitoring and Evaluation.

Socio-economic transformation is addressed in section 3.8 of Volume 3. The studies conducted during the EIA indicate that there will be no relocation of homesteads or graves for the project, however, should there be any chance encounter the requirements under the Heritage Management (EMPr Section 10.10) must be followed.

4.4.3 Land Access Arrangements and Interactions with Landowners

The Contractor shall respect the property and rights of landowners, land occupiers and affected individuals and shall treat all such persons with courtesy. Disruption to the daily lives of landowners, land occupiers and individuals near any working area shall at all times fall within the targets set in the approved Method Statement and EMPr section 10.2.

Access procedures to affected properties shall be as follows:

- No property shall be accessed without prior appointment.
- The Employer shall give the Contractor right of access to the Site in terms of the Contract. The Engineer shall introduce the Contractor to the landowners, and the Contractor shall make himself available for this introduction within 28 days of such access being given.
- The Contractor shall inform the landowner and occupier, if applicable, telephonically or in person about the proposed date for the commencement of activities one month prior to commencing such activities on the property. The Contractor shall follow up with each landowner two weeks before the commencement of activities and again three days before commencement.
- The Contractor shall keep a register of communications with landowners. These records shall indicate time, subject, and outcomes of discussions. The register shall be shared monthly with TCTA via the Engineer, and this register shall be kept up to date and at the completion and hand over of the project, the final register shall be submitted to TCTA via the Engineer.
- The Contractor shall set up a “kick off” meeting with each landowner to discuss all aspects related to the access and Works on the property and to agree on specific requirements, which shall be in writing and made available to the Engineer. The Engineer and TCTA shall also be represented at these meetings. Signed records of any agreements with landowners shall be made available to the Engineer.
- In limited instances, i.e., for survey requirements, where there is a requirement for access outside the Site, appropriate arrangements in terms of this section of the report shall be made with the landowners, and the Engineer shall be informed prior to such access. When the Contractor enters a property in this regard, the Contractor shall report to the owner/person responsible for the property before commencing with any activities, and on completion thereof:
  - i) The Contractor shall obtain signed approval from the landowner/occupier allowing the Contractor access to this property;
  - ii) The Contractor shall obtain sign off after work is completed from the landowner/occupier; and
  - iii) If any access is refused, the Engineer must be informed and no further interaction between the Contractor and landowner/occupier should take place until further instructions are issued by the Engineer.
- The Contractor and all people in his service shall carry official project identity documents.
- The Contractor and his subcontractors may only work in the site areas as indicated on the drawings.
- In addition to the above, the contractor shall ensure that the properties of the landowners remain intact and ensure that the gates are kept locked at all times, unless found open

4.4.4 Complaints Records

The Contractor shall maintain an issues / complaints / grievance register in which is recorded all issues raised by landowners / occupiers, communities or the general public about construction activities. The register shall be updated regularly and used to record the name of the complainant, his or her domicile and contact details, the nature of the complaint and any action taken to resolve the complaint. The complaints register shall be audited monthly. The issues will be discussed between the Contractor and Engineer on a weekly basis, and the complaints register shall be submitted to the Engineer on a monthly basis. The Contractor shall also maintain a compliment / positive feedback register. Recordings on both the complaints register and compliment register will be made available to TCTA on a monthly basis.

Complaints (instances in which a landowner or occupier is dissatisfied with any aspect of the Contractor's behaviour) and claims (instances in which a landowner or occupier demands compensation for damages caused by the Contractor or as restitution for the cause of a complaint) shall be handled in the following manner:

a) If a concern / complaint is raised with the Contractor, the Contractor shall encourage the complainant to put it in writing and sign it, or assist the complainant to put it in writing on their behalf and to have the complaint signed or otherwise authenticated by the complainant.
b) Complainants' concerns and claims against the Contractor should be reported verbally, or telephonically (or by means of telephone messaging such as WhatsApp) to the Engineer's Environmental Officer within 08 (eight) hours of receipt, to be followed up by a formal written communiqué within 24 (twenty four) hours.
c) The Engineer's Environmental lead will enter the complaint / claim against the Contractor in central complaints register. After the claim against the Contractor is settled / an answer is given, the solution must be recorded as such in the register. Until such time as a solution is noted the claim against the contractor / complaint remains active / relevant.
d) The Engineer's Environmental Lead will acknowledge receipt of the complaint verbally and in writing and provide copies of the complaint and acknowledgment of receipt to the complainant, the Contractor and Employer. The Engineer's Social Management personnel will ensure that the complaint is forwarded to the appropriate person.
e) The nature of the complaint / claim against the Contractor will determine the reaction time but should be resolved timeously to avoid long suspensions of the affected and/or their negative reactions due to delays on closing out of the reported complaint. An initial response should be given to the landowner in 48 (forty-eight) hours unless it is an emergency, in which case a response should be made sooner.

4.4.5 Stakeholder Communication and Community Engagement

The purpose of stakeholder and community engagement is to give effect to the need for building good relations, transparency, and inclusion in the process of implementing the project. The

Contractor shall liaise with the project stakeholders and affected communities prior to the commencement of site establishment, and this shall be maintained for the duration of the contract's life cycle (e.g., site establishment). Such liaison shall take place within the framework of the TCTA developed Stakeholder Engagement Plan. The Contractor is required to adhere to the approved method statement on SM and work closely with the Engineer's Environmental Management team in this regard. These shall be achieved through structured engagement as described below:

Stakeholder engagement shall be carried out by means of the following:

- Scope and maintain the existing TCTA developed stakeholder database.
- Develop and implement a grievance resolution procedure, a template of which should be approved by the Engineer.
- Existing structures will be utilised for engagements and where necessary new structures will be established.
- Agreed upon meetings with the structures (e.g., monthly/quarterly) will be conducted and honoured and records of the meetings produced.
- Facilitate the reinstatement of assets and rehabilitation where necessary.
- The contractor shall contribute in TCTA producing information that will inform stakeholders of project progress and of any matters relating the project that need to be brought to their attention, e.g., through the Background Information Document (BID) and newsletters.
- Liaise with landowners and community members with regard to environmental disruptions/disturbances.
- Agreements made prior to construction with respect to property access, the duration of construction and the impacts on the land should be adhered to by both the landowner and the contractor and records of such provided by the contractor.
- Provide the relevant and correct contact details to landowners and community members for queries / raising of issues or complaints.
- Comply with the Access Control Plan, which facilitates access to properties, and inform the Employer of any necessary deviations if required.
- Carry out activities aligned with the Employers approved Communications/Reputation Management Plan.
- Adhere to agreements made prior to construction with respect to property access, the duration of construction and the impacts on the land
- Work with the Environmental Lead to resolve challenges and maintain good stakeholder relations.

In an effort to manage potential socio-political issues, the Contractor shall establish an information office in the relevant local municipalities prior to physical construction to enable the dissemination of accurate project information. The office may be on the project site or away from it. This office may simultaneously serve as an independent recruitment and labour desk if it is away from site. Should the contractor decide to establish the information office on site, then a labour desk should be established elsewhere, away from site.

4.5 ENVIRONMENTAL AWARENESS CREATION AND TRAINING

To be undertaken in compliance with the EMPr.

4.6 NON-HAZARDOUS AND HAZARDOUS SUBSTANCES, POLLUTION AND WASTE

To comply with the requirements of the EMPr.

4.7 MANAGEMENT OF SITE

4.7.1 Preservation of Soil

To comply with the requirements of other sections of the Modular Standards.

4.7.2 Stockpiles

To comply with the requirements of other sections of the Modular Standards.

4.7.3 Watercourses and Waterbodies

To comply with the requirements of Section MS8.

4.7.4 Protection of Flora and Fauna

To comply with the requirements of the EMPr.

4.7.5 Prevention and Control of Fire

To comply with the requirements of the EMPr.

4.7.6 Accidental Leaks and Spillages

With regards to leaks and spillages, the following shall be adhered to by the Contractor:

a) Proper emergency response procedure to be in place for dealing with spills and leaks.
b) Ensure that the necessary materials and equipment for dealing with spills and leaks are available on site, where practicable.
c) Remediation of the spill areas will be undertaken to the satisfaction of the Engineer.
d) In the event of a hydrocarbon spill, the source of the spillage shall be isolated and contained. The area shall be cordoned off and secured. The Contractor shall ensure that there is always a supply of an appropriate absorbent material readily available to absorb, breakdown and where possible, encapsulate a minor hydrocarbon spillage.
e) All staff on site shall be made aware of actions to be taken in case of a spillage.
f) Contact details of persons to be notified in a case of spillages shall be available. Signage to be displayed at strategic points within the construction domain (e.g. workshop, fuel storage area, hazardous material containers).

g) All Major Incidents (i.e. uncontrolled release of a hazardous substance, including from a major emission, fire or explosion, that causes, has caused or may cause significant harm to the environment, human life or property) to be reported to the DFFE and/or other relevant authorities.

4.7.7 Dust Control

To comply with the requirements of other sections of the Modular Standards.

4.7.8 Noise Control

To comply with the requirements of the EMPr.

4.7.9 Erosion Prevention and Drainage Management

The Contractor shall take all reasonable measures to limit erosion and sedimentation caused by the construction activities and shall include in the design, implementation and maintenance of the site Works suitable measures to prevent such occurrences. The Contractor shall protect areas of the construction site that are susceptible to erosion (e.g. steep sections), through suitable measures (e.g. watering, planting, retaining structures, commercial anti-erosion compounds). Where erosion and/or sedimentation occurs, whether on or off the Site, rectification shall be carried out, and the cause of the erosion and/or sedimentation shall be remediated. Any erosion channels caused by construction activities to be suitably stabilised and rehabilitated.

The Works shall be phased and development staged so that the extent of the stripped areas are kept to a minimum at any one time. The Contractor shall ensure that the stabilisation of cleared areas is actively managed in order to prevent and control erosion. Consideration and provision shall be made for various methods, for example *brushcut* packing, mulch or chip cover, straw stabilising (at a rate of one rectangular bale / 20 m^2 and rotovated into the top 100 mm of the completed earthworks), watering, soil binders, anti-erosion compounds, mechanical cover or packing structures, energy dissipaters or establishment of temporary vegetation. Where cleared areas will be exposed for extended periods of time, consideration shall be given to the establishment of temporary vegetation.

Surface stormwater shall not be allowed to be concentrated and to flow down, cut or fill slopes or along pipeline routes without erosion protection measures being in place. Accordingly, the necessary temporary and permanent drainage works shall be installed as soon as possible.

The landscaping and rehabilitation of disturbed areas shall occur as soon as practically possible following the completion of construction of the work in a specific area. Traffic and personnel movement over stabilised areas shall be restricted and controlled and any damage to a stabilised area shall be repaired and maintained.

4.7.10 Excess Material or Spoil

Surplus or unsuitable material shall be spoiled at designated spoil sites.

In operating the spoil sites, the Contractor shall ensure that:

a) Topsoil that would have been buried as a result of the spoiling of material is moved to one side and replaced over the spoil site on completion;
b) The spoil sites are shaped to blend with the local topography as far as is practicable and do not have slopes with a gradient exceeding 1:5 (V:H);
c) Drainage is provided to control ground water exit gradients within the spoil dumps such that the migration of fine materials is kept to a minimum; and
d) Surface water runoff is appropriately channelled through or around the spoil sites to prevent erosion damage resulting from stormwater runoff. In this regard perimeter drainage channels shall be provided and lined with rock or other suitable material to prevent scour, so that runoff will be collected and conducted past the spoil dumps.

The surface of spoil dumps shall be rehabilitated.

4.7.11 Site Rehabilitation

To comply with the requirements of the EMPr.

4.7.12 Management of Archaeological and Cultural Features

To comply with the requirements of the EMPr.

4.7.13 Lighting

To comply with the requirements of other sections of the Modular Standards.

4.7.14 Servicing and Repair of Contractor's Equipment and Vehicles

The Contractor shall service or repair Contractor's Equipment and vehicles only at the Contractor's workshops and in such a manner so as to avoid any environmental contamination (e.g. use of drip trays).

The Contractor shall only be allowed to service or repair Contractor's Equipment in the construction servitude, in case of:

- Emergency repairs, e.g. repair or burst hydraulic hoses and pipes, removal and installation of a gearbox during equipment breakdown, etc.; and
- Routine minor maintenance carried out by the operator of the Equipment, e.g. daily greasing of linkages, etc.

Suitable drip trays and spill clean-up materials shall be used for all the above work.

No washing of plant may occur on the construction site. Equipment to be washed in dedicated areas.

Drip trays to be provided for stationary parked Equipment.
All vehicles and equipment must be kept in good working order and serviced regularly. Leaking equipment will be repaired immediately or removed from the site.

Suitable storage and disposal of hydraulic fluids and other vehicle oils are required.

4.7.15 Construction Camps

With regards to the construction camps, the following shall be adhered to:

a) Erect suitable fencing around the construction camp;
b) The construction camp may not be situated within 100 metres of any water body or within the 1:100 year flood line;
c) Provide essential services (including appropriate sanitation and drinking water facilities) at the construction camp and maintain essential services in a functional state;
d) Provide safe potable water for food preparation and drinking;
e) Provide adequate parking for site staff and visitors;
f) Open fires and cooking will be forbidden at the site camp;
g) Eating areas to be designated and demarcated. Closed waste containers to be provided at all eating areas;
h) The feeding, or leaving of food for animals, is strictly prohibited;
i) Sufficient vermin / weatherproof bins will be present in this area for all waste material;
j) Ensure that wastewater is appropriately disposed of;
k) Locate all storage areas and material laydown sites within predetermined zones as per the approved site plan;
l) Keep the camp and all its storage and laydown areas secure, clean and neat at all times;
m) Employ appropriate access control measures;
n) Suitable security to be provided at the construction camp at all times;
o) Manage storm water from construction camp to avoid environmental contamination and erosion;
p) Prohibit the felling of trees for firewood;
q) Provide medical and first aid facilities at the camp area;
r) Prepare de-establishment plan for construction camp for review by the Engineer; and
s) Provide fire fighting equipment at the camp area.

4.7.16 Ablution Facilities

With regards to ablution facilities, the following shall be adhered to:

a) Provide sufficient ablution facilities (e.g. mobile / portable / VIP toilets) at the construction camp and along construction sites, which conform to all relevant health and safety standards and codes;
b) No pit latrines, French drain systems or soak away systems shall be allowed. Install and maintain conservancy tanks for any site offices.
c) Toilets may not be situated within 100 meters of any water body;
d) A sufficient number of toilets shall be provided to accommodate the number of personnel working in any given area. Toilets may not be further than 100 m from any working area. Toilet facilities supplied by the Contractor for the workers shall occur at a maximum ratio of 1 toilet per 15 workers;
e) All temporary / portable / mobile toilets shall be secured to the ground to prevent them from toppling over due to wind or any other cause;
f) Ensure the proper utilisation, maintenance and management of toilet, wash and waste facilities;
g) The entrances to the toilets shall be adequately screened from public view;
h) These facilities will be maintained in a hygienic state and serviced regularly;
i) Toilet paper shall be provided;
j) The Contractor shall ensure that no spillage occurs when the toilets are cleaned or emptied and that a licensed service provider removes the contents from site. Disposal of such waste is only acceptable at a licensed waste disposal facility (proof of disposal to be provided);

4.7.17 Visual Aspects

With regards to the management of visual aspects, the following shall be adhered to:

a) Advertising and lighting will be in accordance with relevant standards;
b) The Site must be shielded /screened to minimise the visual impact, where practicable;
c) On-going housekeeping to be maintained to ensure a tidy construction area; and
d) After the construction phase, the areas disturbed that are not earmarked for operational purposes (part of infrastructure footprint) must be suitably rehabilitated.

4.7.18 Labour Force

With regards to the management of labour force, the following should be adhered to:

a) Prohibit trespassing of construction workers on private property;
b) Workers must be provided with identity cards and wear identifiable clothing;
c) Creating nuisances and disturbances in or near communities shall be prohibited;
d) Machine / vehicle operators shall receive clear instructions to remain within demarcated access routes and construction areas;

e) Ensure that operators and drivers are properly trained and make them aware, through regular toolbox talks, of any risk they may pose to the community. Place specific emphasis on the vulnerable sector of the population such as children and the elderly;
f) Designated smoking areas must be provided, with special bins for discarding of cigarette butts; and
g) No staff accommodation shall be allowed on site.

4.7.19 Access and Traffic

To comply with the requirements of the EMPr.

4.7.20 Cement and Concrete Batching

The following shall be adhered to:

a) Cement mixing to take place on an impervious surface (e.g. cement mixing pit);
b) Batching operations to take place in a designated area, which shall be kept clean at all times;
c) Location of batching plant to be approved by the Engineer, with due consideration of the relevant management measures contained in the EMPr;
d) Separation of clean and dirty water from batching plant to be ensured;
e) Wastewater from batching operations to be appropriately and legally disposed of. Contaminated water will not be discharged to the environment. Overflow from contaminated wastewater storage area to be prevented;
f) Waste concrete and cement sludge to be removed on a regular basis (to prevent overflowing) and to be disposed of at a suitable facility;
g) Unused cement bags to be stored in an area not exposed to the weather and packed neatly to prevent hardening or leakage of cement;
h) Used cement bags to be stored to prevent windblown dust and potential water contamination. Used bags to be disposed of adequately at a licenced waste disposal facility. No burning of cement bags will be allowed;
i) Concrete transportation and pouring must not result in spillage;
j) Cleaning of equipment and flushing of mixers must not result in pollution, with all contaminated wash water entering the waste water collection system;
k) To prevent spillage onto roads, ready mix trucks must rinse off the delivery shoot into a suitable sump prior to leaving the Site;
l) Suitable screening and containment must be in place to prevent windblown contamination from cement storage, mixing, loading and batching operations;
m) All contaminated water and fines from exposed aggregate finishes must be collected and stored in sumps and be adequately disposed of; and
n) All visible remains of excess concrete must be physically removed on completion of the plastering or concrete pouring and disposed of in an acceptable manner.

4.8 BUFFER ZONES

The Contractor shall take cognisance of the following buffer zone requirements in all its operations. These buffer zones shall be included on site layout plans and made known to all Contractor's Employees through induction training and regular toolbox talks.

TABLE 4/1
BUFFER ZONES

ACTIVITY	BUFFER	MEASURE
Mixing areas, stockpiles and laydown yards	30 m	Located from the edge of the delineated riparian zone.
Development footprints	50 m	Buffer area to be kept clear between any development footprints and construction activities and heritage sites.
Dust Emissions	200 m	Dust emissions from unpaved roads situated within 200 m of any communities, school or other gathering point must be reduced (through the application of a surface binding agent and/or watering) especially in windy conditions, where exposed soil may generate significant dust and/or if complaints are received.
Storage of Hazardous Materials in sensitive areas	100 m	The containment of fuel, lubricants / oils, chemicals, hazardous waste and hazardous material must not be located within 100m of any river, stream and/or wetland.
Refuelling or Emergency Repairs	50 m	Where refuelling or emergency repair of vehicles or machinery is required, this must not occur within 50 m of river/ stream banks, wetlands, or within the 100-year floodline, whichever is applicable.
Washing of vehicles and equipment	50 m	Dedicated areas for washing of vehicles and equipment must be demarcated, and not be located within 50 m of any river, stream or drainage line.
Toilet Facilities	100 m	Sanitation facilities shall be limited to mobile chemical toilets and these shall not be located closer than 100 m to any water body (river, stream or wetland).
Deposition of Top Soil	50 m from river or wetland edge	Soil stockpiles to be located at least 50 m from the edge of wetlands, streams or rivers; areas prone to flooding, or where the flow of water could cause ponding of water or soil erosion.

4.9 MONITORING

Monitoring is required to ensure that the receiving environment is suitably safeguarded against the identified potential impacts, and to ensure that the environmental management requirements are adequately implemented and adhered to during the execution of the project.

4.9.1 Pre-construction (walk-down) Survey

The Contractor shall conduct a pre-construction survey for all areas that are to be affected by construction activities. The survey needs to include the following:

- Site investigations by appropriate members of the project team and specialists (as relevant);
- Generate records from survey which include site details, photographs and videos, explanatory notes, etc. (as required);
- Record the condition of existing structures and infrastructure on the site; and
- Identify site-specific mitigation measures.

The records from the pre-construction survey must be used to establish and inform the reinstatement and rehabilitation requirements for the affected areas.

4.9.2 Environmental Monitoring

Environmental monitoring entails checking, at pre-determined frequencies, whether thresholds and baseline values for certain environmental parameters are being exceeded. The parameters and sampling localities used during the baseline monitoring will form the basis of the environmental monitoring programme. All environmental monitoring shall be carried out by the Contractor under the supervision of an appropriately qualified professional service provider. In this regard, the Contractor shall submit to the Engineer for approval a detailed terms of reference for the appointment of the professional service provider to undertake the environmental monitoring programme for the identified environmental parameters.

The environmental parameters to be included as part of the environmental monitoring programme, which is to be undertaken by the Contractor during the construction phase, include the following:

a) Air Quality – Dust fallout
b) Noise; and
c) Water quality and biomonitoring;

The following requirements need to be incorporated into the programme:

a) Monitoring during normal operations, abnormal situations and emergency situations (e.g. unexpected spillage of hazardous substance);
b) Measuring equipment must be accurately calibrated;
c) Adequate quality control of the sampling must be ensured;
d) Analysis is to be undertaken at a SANS 17025 certified laboratory;

e) Certified methods of testing must be employed;
f) Where legal requirements exist for testing and sampling methods, these must be taken into account; and
g) Establish a process for identifying and implementing corrective measures.

The professional service provider shall be required to fulfil the minimum professional requirements for:

a) Qualifications;
b) Professional registration;
c) Experience and track record;
d) Demonstrated proficiency in use of relevant monitoring and sampling equipment;
e) Equipment requirements and tolerances for detection limits;
f) Reporting and analysis; and
g) Confirmation of laboratory accreditation, capacity, delivery and performance within reasonable timeframes.

4.9.3 Environmental Monitoring Variables

4.9.3.1 Air Quality

Dust monitoring must be carried out in accordance with the National Environmental Management Air Quality Act (Act No.39 of 2004). The monitoring shall determine the existing dust fallout levels at selected positions at the Works, borrow areas, and along access and haul roads.

Dust levels on site shall not exceed 15% above the ambient.

Where communities or concentrations of homesteads are located in the proximity of the pipeline alignment or borrow pits, the monitoring of PM10 dust particles must also be conducted in order to determine the potential health impact of the fine dust on the receptors in accordance with SANS 1929:2011: Ed2.00 standard.

The method for sampling will be according to the American Society for Testing & Materials standard method for collection and analysis of windblown dust deposition (ASTMD1739).

The Contractor shall provide, maintain and regularly calibrate dust measurement equipment.
Dust measurement will be required at those portions of the working area where work is actively occurring, and at borrow pits. The exact number and location of individual collectors shall be established in consultation with the Engineer.

The Contractor shall keep records of all dust level measurements for the duration of the Contract. These records shall be submitted each month to the Engineer in an agreed format. The records shall provide calculated average values for each month, include appropriate meteorological data recorded, and shall be accompanied with action plans for improvement where standards are not met.

4.9.3.2 Water Quality and Biomonitoring

Water quality monitoring shall be conducted as per Section10.5 of the EMPr.

4.9.3.3 Noise Levels

Noise monitoring on site will be carried out in accordance with the South African National Standard - Code of practice, SANS 10103:2008 – the measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication. The Contractor shall provide and maintain equipment to measure noise levels on site. This monitoring equipment will comply with the following international standards:

- IEC 651 & 804 – Integrating sound level meters; and
- IEC 942 – Sound calibrators.

Typically, the sound measuring instruments to be used would be a 01dB SIP95 Data-logging Precision Impulse Integrating Sound Level Meter and Calibrator, or similar.

The Contractor shall calibrate the noise monitoring equipment as required and maintain records of calibration.

Noise measurement will be required at the established monitoring sites. The exact number and location of individual monitoring sites shall be established in consultation with the Engineer. Noise measurements shall comprise 4 to 6 measurements of 10 minutes each at evenly spread intervals over the course of a day for each site.

The Contractor shall keep records of all noise level measurements for the duration of the Contract. These records shall be submitted to the Engineer on a monthly basis in an agreed format, and shall be accompanied with action plans for improvement where standards are not met.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 5

SURVEY AND SETTING OUT

TCTA MODULAR STANDARDS
SECTION 5
SURVEY AND SETTING OUT

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SECTION 5
SURVEY AND SETTING OUT

5.1 SCOPE

This Section deals with the requirements for the setting out of the Works, survey control and measurement required for survey of the Works.

5.2 DEFINITIONS

5.2.1 Definitions

a) **"Absolute accuracy"** is defined as the accuracy of any individual reference mark within the Survey Network.

b) **"Control Beacon"** means a subsidiary survey control point that is to be used for setting out of the Works. All subsidiary survey beacons and bench marks that are placed, either by the Engineer or Contractor, for control and setting out of the Works shall be set out with reference to the Project Reference Marks.

c) **"Bench Mark"** is a survey control point that is used for undertaking all type of engineering survey including setting out of levels on the construction Works.

d) **"GPS"** means Global Positioning System.

e) **"IMU"** means Inertial Measurement Unit.

f) **"LiDAR"** means Light Detection and Ranging.

g) **"LiDAR – Survey/Aerial mapping"** is an aircraft or drone-based remote sensing technology, using laser scanning to measure the shape of the ground surface.

h) **"Project Reference Marks"** mean the primary survey control points which have been fixed within the Contract coordinate system by the Engineer for the purpose of survey reference and setting out. Although the system is based on the WGS 84 Hartebeeshoek 94 datum Lo 27 co-ordinate system it has been refined for use in this Contract due to unavailability of reliable elevation control in the Contract area.

i) **"Relative accuracy"** is defined as the accuracy of a reference mark relative to its closest neighbouring reference marks.

j) **"UAV/Drone based surveys"** means surveys done using a suitable unmanned aerial vehicle or drone piloted by remote control by a qualified operator.

k) **"Trigonometric Stations (Trig Beacons)":** means any survey station, including a town survey mark, erected by or under direction of the Chief Director as part of the national control survey system and for which he or she has published, or intends to publish, official co-ordinate values, and includes such other stations as may be prescribed

5.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions

thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

5.3 GENERAL

This Section shall be read together with the requirements of Clause 4.7 of the Conditions of Contract regarding setting out.

All reference points given on the drawings are based on the project coordinate system. Dimensions of structures given on drawings are corrected for the mean level of the Works above sea level unless specifically stated otherwise and shall be used without further correction.

To avoid any errors, only the Project Reference Marks, location and survey coordinates indicated on the drawings should be used for all construction setting-out and level purposes.

All necessary sight rails, pegs, and other items required for the proper alignment of the Works shall be erected by the Contractor to the satisfaction of the Engineer. The Contractor shall record all field observed data calculations for setting out and check surveying in a suitable permanent form, which shall be available to the Engineer on request at all times. These records shall accompany field setting out sketches showing the setting out marks, templates, stakes, batter boards, beacons and pegs, etc., and their relation with the Permanent Works. The Contractor shall supply two copies of any such calculations to the Engineer on request through the document control system where the Engineer will then sign the transmittal to acknowledge receipt.

The Contractor shall, at his own expense, make all templates where necessary for the proper setting out of the Works and support of items to be built in. All surveying works shall be recorded on hard copies and electronic format, and kept available for the Contractor and the Engineer.

The Contractor shall have available on site at all times a sufficient number of properly maintained GPS’s, total stations, levels, laser equipment, accurate steel tapes, ranging rods, boning rods, and other instruments and appliances as may be necessary for the correct setting out of the Works and control of the construction process and the calibration of all survey equipment shall be done as per the manufacturers’ specifications.

The Contractor shall also maintain regular UAV/drone surveys at monthly intervals that are aligned with the selected construction production rates. These surveys shall capture all stages of the construction process at a specific site or along a progressing linear train of sequential production operations. It shall also include the active borrow pits and spoil areas where relevant. In parallel with the execution of these surveys still images shall be taken as part of the photographic record.

The Contractor shall comply with OHSAct 85 of 1993 and Construction Regulations 2014.

5.4 CONTROL BEACONS

5.4.1 Project Reference Marks and Line Control

Project Reference Marks (PRMs) have been established by the Engineer adjacent to the Works. These PRMs shall be the sole points of reference for setting out and levelling purposes. The Contractor is required to check the internal consistency of the PRMs.

The Contractor shall note that the PRMs have been surveyed and the results reduced to reflect the following accuracies for the reference marks within the Project Ground Control Survey Network:

TABLE 5/1
ACCURACY LEVEL OF PRM POINTS

DISCIPLINE	ABSOLUTE ACCURACY	RELATIVE ACCURACY
Control Point Horizontal Position (Y and X)	100 mm	20 mm
Control Point Elevation (Level)	100 mm	10 mm

These PRMs consist generally of a 12 mm round steel peg placed in 250 mm diameter concrete, 200 mm deep and identified with a stamped metal tag. Where these PRMs are located outside of the servitude area they should be marked with at least 3 clearly visible Y-standards painted white, spaced equally around the PRM, of appropriate length to be visible above grass and shrubby vegetation, placed adjacent to the PRM.

The coordinates and reduced levels of the PRMs are provided on the drawings.

5.4.2 Internal Consistency of PRMs

Before commencing construction of any part of the Permanent Works, the Contractor shall check that all the PRMs established by the Engineer are internally consistent and are sufficiently accurate for the construction of the Works to the required tolerances. The Contractor shall either notify the Engineer of any discrepancies found or confirm his acceptance of the said PRMs.

5.4.3 Subsidiary Beacons, Survey Stations and Bench Marks

The Contractor shall establish, permanently tag and protect subsidiary beacons, survey stations and benchmarks required for accurate setting out and level control during construction of the Works. Survey stations shall be of rigid construction and be protected from damage and the design and construction thereof shall be agreed with the Engineer. Pegs placed by the Engineer which may be disturbed during construction shall be referenced by the Contractor by surveying and placing other

pegs nearby in safe positions and all such pegs shall be carefully protected to the satisfaction of the Engineer.
The Contractor shall ensure that the necessary ground control are in place prior to every UAV/drone survey.

The Contractor shall supply the Engineer with the coordinates, levels and other relevant information relating to subsidiary beacons, survey stations and bench marks.

5.5 PRESERVATION AND REPLACEMENT OF PROJECT REFERENCE MARKS

Once the Site has been handed over to the Contractor he shall take responsibility for the safeguarding of all the PRMs which will be used to set out and construct the Works. If at any time during the construction of the Works the Engineer suspects that one of the PRMs previously established by the Employer has been disturbed, the Contractor shall have the PRM surveyed and the benchmark re-levelled. Any setting out which was undertaken after the PRM and/or benchmark was disturbed shall then be rechecked and corrected if necessary, including any remedial work required for the Works, by the Contractor without any additional payment.

Where a PRM, beacon or benchmark is likely to be disturbed during construction operations, the Contractor shall establish suitable replacement reference beacons or benchmarks at locations where they will not be disturbed during construction. No PRM, beacon or benchmark shall be covered, disturbed or destroyed before accurate replacement reference beacons or benchmarks have been established and details of the position and levels of such replacement beacons or bench marks have been submitted to the Engineer for review. These replacement PRMs, beacons or benchmarks shall be placed to avoid damage to property or injury to animals and should be marked as required.

The Contractor's reference beacons or benchmarks shall be of at least the same quality and durability as that of the existing PRMs and benchmarks.

The Contractor shall be responsible for the safety of any Government survey beacons, survey benchmarks, PRMs and boundary beacons encountered. If any reference points are disturbed or destroyed by the Contractor, they shall be replaced without additional payment to the Contractor, within three weeks where these points falls within the working area, by a Registered Land Surveyor.

5.6 SURVEY OF GROUND PROFILES

5.6.1 Original Ground Profiles

The Employer has through a LiDAR survey obtained original ground levels, to a resolution of 100 mm or better (for an estimated 80% of the results) in horizontal and vertical position, of the Contract area, approximately 350 m to either side of the pipeline centreline and including those borrow pits and spoil areas located outside the pipeline survey corridor. The results of the LiDAR survey (x, y, z points) will be made available in electronic format.

For the purpose of the Contract, the LiDAR survey data shall define the original ground profiles.

5.6.2 Excavated, Final Ground Profiles and Constructed Levels

The Contractor shall survey all excavated and final surfaces for the purpose of recording as-built details and, where applicable, for the measurement of quantities. Specifically the aims of this survey are:

a) Confirmation of actual rock levels;
   - Method 1: On completion of excavation to rock level and prior to commencement of drilling and blasting;
   - Method 2: On completion of excavation to the final required level, subsequent to drilling and blasting, the actual rock level is to be marked and surveyed as part of the final excavation survey;

b) Confirmation of actual final excavation levels on completion of the excavation and prior to placing bedding, concrete or other work and after placing bedding and prior to pipe laying and backfilling;

c) Confirmation of backfilled levels: On completion of placing backfill, concrete or other work;

d) Confirmation of bottom and top of floors, top levels of structures, invert and top of slab levels, top of plinth levels for pumps and any other levels required by the Engineer; and

e) Confirmation of Final Ground Profiles: On completion of landscaping and topsoiling.

5.7 SETTING OUT OF THE WORKS

5.7.1 General

The Contractor shall perform all setting out and check surveying of the Works and follow the ISO Quality Management System. The number of points required for setting out as well as the spacing between these points shall be determined by the Contractor in accordance with the type of the work.

The Contractor’s methods and programme of checking shall be such as to ensure the construction of every part of the Works to the correct line and level, subject to the tolerances specified. The Engineer may at any time request the Contractor to submit proof that the setting out has been satisfactorily checked.

Specific to all set out sections of the Works, the Contractor shall ensure that the following are implemented and adhered to on site:

- Quality and specifications, and where such is unclear, the Engineer be consulted for clarification;
- The latest revision construction drawings are used on site; and
- All drawings are controlled as per the Contractor’s Quality Control system.

5.7.2 Setting Out for Underground Work

The Contractor shall use a suitable system whenever possible to control the alignment of underground work and shall use suitable precision survey equipment for setting out and check surveying.

If at any time during the excavation, it is evident that the alignment of the excavations is outside the specified tolerances then, before proceeding further with the excavation, the Engineer and the Contractor shall agree the necessary corrections to the alignment, and the Contractor shall forthwith make the said corrections.

5.7.3 Setting Out for Pipe Works

The Contractor shall install sufficient sight rails, batter boards, pegs, level markers or other survey points to accurately control construction of the pipeline, structures and services. Where necessary or specified, the Contractor shall install a laser system to control construction of certain aspects of the work as applicable.

The Contractor shall check the actual ground cover above the top of the pipe as shown on the drawings that can be obtained relative to the actual ground levels at the pipe centreline at least 21 days prior to commencement of the trench excavation.

The Contractor shall carry out an accurate survey of the levels of structures interfacing with the pipeline to ensure that the specified levels and layout relative to the pipeline have been achieved.

5.8 SETTING OUT CHECKS

The Engineer will undertake regular check surveys during the course of construction and the Contractor shall cooperate with and provide assistance for this as required by the Engineer.

The Contractor is expected to liaise with the Engineer to programme the setting out check surveys to be carried out during non-production periods or in parallel such that the minimum delay or inconvenience is caused to production work, wherever and whenever possible. The Contractor shall afford the Engineer every cooperation and assistance in this regard including, but not limited to, the provision of drainage, lighting and ventilation and the removal or placing of Contractor's Equipment and other obstructions such that they do not interfere with the setting out checks.

5.9 SITE BASED LASER TERRESTRIAL SURVEY REQUIREMENTS

5.9.1 General

Clause 5.9 is only applicable if a site based laser terrestrial survey is specified in the project specifications or employer’s requirements or pricing data in the contract documents.

The Contractor shall provide and maintain fully integrated UAV/Drone based LiDAR survey technology combined with high resolution still image camera technology and IMU/GPS systems for the duration of construction. This technology is required for cost efficient construction production surveying, improved accuracy of measuring and agreeing quantities when required, producing accurate construction records and creating detailed sequential areal photographic progress records.

5.9.2 Equipment and Operators

The equipment shall include the drone (UAV), LiDAR point cloud sensor. Camera, geo-referencing trimble, accessories, custom mounts, software and spares. The equipment shall be compatible with the LiDAR information provided by the Engineer.

The equipment shall be operated by fully qualified drone pilots and data processing staff.

The Contractor shall submit a detailed method statement for review by the Engineer prior to commencement of this function. The Engineer reserves the right to reject equipment that is not reliable or does not produce the required quality as specified below.

5.9.3 UAV Trajectory

The following minimum performance aspects are applicable:

a) Minimum requirements for the GPS/IMU combination are:
   - GPS frequency minimum of 1 Hz; and
   - IMU minimum frequency of 100 Hz.

b) Post-processing is required and a maximum error of 50 mm is required for the final trajectory.

5.9.4 LiDAR Points

The following minimum performance aspects are applicable:

a) LiDAR point cloud is required. No photogrammetric point clouds or hybrid point clouds shall be permitted;
b) LiDAR point density shall be minimum 100 points per square metre;
c) LiDAR points shall be scanned within the trench and separately for volumes above the rock line and below the rock line;
d) Point cloud cleaning of ground features shall be performed;
e) Full swath-to-swath corrections shall be performed and no error shall exceed 50 mm;
f) 3D models shall be developed from which excavation and fill volumes can be measured; and
g) Excavation and fill volumes to be reported in line with the LiDAR data accuracy.

5.9.5 Image Capturing

The following minimum performance aspects are applicable:

a) The image capturing shall be performed with a lab-calibrated metric camera;
b) Images shall be geotagged;
c) Image pixel resolution shall be 40 mm or less;
d) A fixed lens focal length shall be used during flight or image capture. (No adjustment permitted);
e) Full image rectification shall be performed and ortho-images shall be created;
f) Image-to-Image and overall colour balancing and contrast balancing shall be performed;
g) Image seamline correction shall be performed. (No seamlines cuts permitted); and
h) The images shall be submitted in an accessible digital format.

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SECTION 6

FENCING

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SECTION 6
FENCING

6.1 SCOPE

This Section covers the erection, maintenance and where necessary, the removal of all fencing required on this Contract. This includes high level security fences as well as temporary and permanent fences of different types but excludes electrified fences.

6.2 DEFINITIONS

6.2.1 Definitions

The following terms shall have the meanings given:

a) **"Straining posts"** means mild steel tubing spaced at a maximum of 180 m centres unless otherwise shown on the drawings and anchored in such manner to stabilise and strengthen a fence.
b) **"Stays"** which includes inclined or horizontal struts means mild steel tubing required for anchoring of straining posts.
c) **"Standards"** means Y-sections spaced at a maximum of 15 m centres unless otherwise shown on the drawings between straining posts to support and strengthen the fence.
d) **"Droppers"** means ridgeback pattern sections spaced at a maximum of 3 m centres between standards.
e) **"CKS"** means the SANS co-ordinating specifications. CKS 82 = Steel posts, stays, standards, and droppers for strained wire fences.
f) **"Temporary fence / fencing"** means fences erected along the construction servitudes for purposes of demarcating and securing the site and which will be removed on completion of the Works.
g) **"Permanent fence"** means fences erected along the cadastral boundaries of farms, permanent servitudes and sites on drawings or as directed by the Engineer and which will be left in place on completion of the Works.
h) The terms **"fence"** and **"fencing"** are used interchangeably and shall have the same meaning.
i) The terms **"game proof fences"** and **"game fences"** are used interchangeably and shall have the same meaning.

6.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has

subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

6.3 MATERIALS

6.3.1 Posts (corner, straining, gate, etc.), Stays, Standards, Droppers, Wire, Binding Wire, Fencing, Concrete and Gates

6.3.1.1 General

Corner posts, straining posts, stays, standards and droppers shall be the type and size indicated on the drawings.

6.3.1.2 Seven Strand Stock-Proof Fence

Steel sections shall comply with the requirements of CKS 82.

Straining, gate, bend, end and intermediate posts shall be 2.1 m long 88 mm outside diameter by 3 mm wall thickness mild steel tubing, and inclined and horizontal stays shall be 2.1 m and 2.0 m long respectively and of 48 mm outside diameter by 3 mm thick mild steel tubing, unless otherwise shown on the drawings. Standards shall be 1.85 m long 2.50 kg/m rolled steel Y-sections. Droppers shall be 1.25 m long 0.56 kg/m ridged mild steel T-Sections.

All tubular posts shall be provided with a 300 mm x 300 mm x 3 mm footplate with a 10 mm hole in the middle, and a 4 mm pressed-steel or cast-iron cap to prevent any moisture from entering, all as shown on the drawings. Rolled steel sections shall be provided with a protective coating of tar.

Gate posts shall be galvanized mild steel construction members and configurations as detailed on the drawings. All joints shall be welded all round construction 7.4 padlock and chain. Link chain 450 mm long with centre welded to 48 OD pipe and fitted with 30 diameter x 5 diameter ring at each end with padlock.

Barbed wire (in accordance with SANS 675 – 2011) Campeon high–tensile grade steel – strand 2.8 mm x 1.9 mm oval wire with 4 x barbs evenly spaced at 125 mm centres. Binding wire shall be 2.0 mm mild steel for tying posts, droppers and standards.

Bolts for struts shall be 12 mm fully galvanized with nuts and washers. Wire stays shall be 4 mm 8-cord straining wire.

6.3.1.3 Game Fences

Steel sections shall comply with the requirements of CKS 82.

Straining, gate, bend, end and intermediate posts shall be 3.3 m long (2.4 m high fence),114 mm outside diameter x 4 mm wall thickness mild steel tubing, and the inclined struts shall be 3.3 m long x 60 mm outside diameter x 3 mm thick mild steel tubing unless otherwise shown on the drawings. Horizontal struts shall be 2.0 m long x 60 mm diameter x 3 mm wall thickness mild steel. Standards (average 83/km) shall be 3.05 m long, 2.50 kg/m rolled steel Y-section posts. Droppers (average 581/km) shall be 2.45 m long, 0.56 kg/m ridged mild steel T-Section posts.

All tubular posts shall be provided with a 300 mm x 300 mm x 3 mm footplate with a 10 mm hole in the middle, and a 4 mm pressed-steel or cast-iron cap to prevent any moisture from entering, all as shown on the drawings. Rolled steel sections shall be provided with a protective coating of tar.

Gate posts shall be galvanized mild steel construction members and configurations as detailed on the drawings. All joints shall be welded all round construction 7.4 padlock and chain. Link chain 450 mm long with centre welded to 48 OD pipe and fitted with 30 diameter x 5 diameter ring at each end with padlock.

Wire shall be 3 mm diameter mild steel or 2 mm diameter high-tensile steel round wire fully galvanized (yellow label). Binding wire shall be 2 mm mild steel for tying posts, droppers and standards.

Bolts for struts shall be 12 mm fully galvanized with nuts and washers. Wire stays shall be 4 mm 8-cord straining wire.

6.3.1.4 High Security Fences

Gate posts shall be hot-dipped galvanised (Heavy Duty) 140 mm square by 10 mm thick steel tubing, as specified of the drawings and Section 37. Inter-straining, corner and end posts shall be hot-dipped galvanised (Heavy Duty) 120 mm by 120 mm by 15 mm thick mild steel angle. Inter-post shall be hot-dipped galvanised (Heavy Duty) 70 mm by 70 mm by 10 mm thick mild steel angle. Post stays shall be hot-dipped galvanised (Heavy Duty) 70 mm by 70 mm by 10 mm thick mild steel angle.

All posts shall be provided complete with necessary fittings, double leaf overhangs and capped as specified on the drawings.

6.3.1.5 Site Offices

Gate posts shall be hot-dip galvanised (light-duty) 140 mm square x 10 mm thick steel tubing 3.2 m long, as specified on the drawings. Inter-straining, corner and end posts shall be hot-dip galvanised (light-duty) 120 mm x 120 mm x 8 mm thick mild steel angle iron 3.2 m long complete with the necessary fittings. Stay bracings shall be 50 mm x 50 mm x 5 mm thick hot-dip galvanised mild steel angle iron. Inter-posts shall be hot-dip galvanised (light-duty) 70 mm x 70 mm x 8 mm thick mild steel angle iron. Post stays shall be hot-dip galvanised (light-duty) 70 mm x 70 mm x 8 mm thick x 3.2 m long complete with the necessary fitting hot-dip galvanised mild steel angle iron. All posts shall be

provided complete with necessary fittings, double leaf overhangs and capped as specified on the drawings.

Tie-wire (Straining wire to inter-post) shall be 3.0 mm diameter hot-dip galvanised (light-duty). Tie-wire (Flat coils to straining wire) shall be 1.6 mm diameter hot-dip galvanised (light duty) to comply with SANS 675. Bolts and nuts shall be mild steel galvanised to SANS 121. Eye bolts shall be 10 mm diameter (mild steel) that may be welded to post galvanising. No drilling, cutting or welding shall be carried out on mild steel parts after galvanising. All mild steel parts shall be correctly cut, drilled and welded before galvanising.

All stays, stay bracings and gate posts (except the inter and inter-straining posts) shall be sullied in pairs, on the right and left, each complete with the necessary fittings. Mesh shall be 50 mm diamond mesh from 2.5 mm wire to SANS 1373, class B galvanised. The razor cut coil (connection type) shall be attached to the fence.

Concrete

- Gate posts 30/38;
- Intermediates 15/9; and
- Stays 15/9.

6.3.1.6 Gates

Gates shall be as per specified type and dimensions as indicated on the drawings. Where existing gates are replaced it shall be of similar width and equal functions as the existing to maintain comparable access for agricultural activities.

6.3.1.7 Bolts and Hinges

Bolts shall be of stainless steel or fully galvanised to SANS 121 mild steel material, and of the required length and diameter which shall not be less than 12 mm. All the necessary bolts, nuts and washers, shall be supplied with each post.

Gates for stock-proof and game fences shall be mounted on the gate post by means of 30 mm diameter fully galvanised to SANS 121 mild steel eyebolt hinges.

6.3.2 Wire and Mesh

6.3.2.1 Barbed Wire

(a) Seven Strand Stock-Proof Fence

Barbed wire shall comply with the requirements of SANS 675 and shall be Campeon high-tensile-grade steel single-strand 2.8 mm x 1.9 mm oval-shaped fully galvanised wire. Barbs shall be

manufactured from 2.0 mm zinc-coated mild steel wire and shall be evenly spaced at not more than 125 mm.

(b) Game Fences

Barbed wire shall comply with the requirements of SANS 675 and shall be Campeon high-tensile-grade steel single-strand 2.8 mm x 1.9 mm oval-shaped fully galvanised wire. Barbs shall be manufactured from 2.0 mm zinc-coated mild steel wire and shall be evenly spaced at not more than 125 mm.

(c) High Security Fences

Wire shall comply with the requirements of SANS 675 and shall be 3 mm diameter mild steel or 2 mm diameter high-tensile-grade steel round wire (yellow label).

6.3.2.2 Smooth Wire

Smooth wire shall comply with the requirements of SANS 675 and shall be of the types specified below:

a) For high security fences, straining wire shall be Gauge no 8 hot-dipped galvanised (Class A) high-tensile-grade steel wire;
b) Other fencing wire shall be high-tensile-grade steel 2.24 mm diameter hot-dipped galvanised (Class A) wire;
c) Tying wire for security fences shall be hot-dipped galvanised (Class A) and be 3.0 mm diameter mild-steel wire for tying straining wire to inter-posts and 1.60 mm diameter for tying flat coils or welded mesh to straining wire. For stock-proof and game fences tying wire shall be 2.0 mm diameter mild-steel hot-dipped galvanised (Class A) wire for tying to posts, standards and droppers;
d) All diamond mesh (Chain-link fencing) shall comply with the requirements of SANS 1373. The width shall be as shown on the drawings, and both edges shall be clinched; and
e) The diameter of the diamond mesh wire shall be 2.5 mm and the mesh size shall be as shown on the drawings, and the wire shall be Class A galvanized.

6.3.2.3 Weld Mesh

Double line wire mesh shall be fabricated generally in accordance with SANS 10244-2 and shall have an aperture size not exceeding 10 mm. The mesh shall be supplied in sheets of the appropriate height, and shall be fabricated from 4 mm mild steel wire. The wires shall be protected by Zinc Alu Super.

6.3.3 Gates and Padlocks

Gates shall be as per specified type and dimensions as indicated on the drawings and as follows:

Gates shall be fabricated with a 48 mm OD tube frame in accordance with SANS CKS 146 and with the details shown on the drawings. Gates shall be supplied complete with centre and diagonal braces.

Gates for stock-proof and game fencing:	3.6 m to 5.0 m wide and the same height as the fence (i.e. 1.25, 1.8 and 2.4 m high).
Security gates:	3.1 m wide x 3 m high x 2 no. (Double gate).
Gate for Contractor's Establishment Area:	3 m wide x 2.4 m high x 2 no. (Double gate).

Gates shall be complete in every respect, including hinges, washers, bolts and locking chains attached to the gate. Gate material shall be hot-dipped galvanised in accordance with Section 37 - Painting and Corrosion Protection and the drawings.

Security gates shall be provided with one "Multi T-lock" padlock for each gate. Gates for stock-proof and game fencing shall be provided with a 450 mm length of link chain with the centre welded to 48 mm outside diameter pipe, and fitted with a 30 mm diameter x 5 mm ring at each end with a padlock. Padlock keys to be duplicated for all the locks with a maximum of 10 keys per padlock. Each gate shall have two locks, the Contractor's and the farmer's, and shall lock into each other. Both parties will therefore have access.

The Contractor shall provide a method statement describing key and access control.

6.3.4 Steel Palisade Fences

Steel palisade fences shall be 1.2 m, 1.5 m, 1.8 m, 2.0 m, 2.4 m or 3.0 m high, with spiked pales of hot rolled equal angle iron 25 x 25 mm, 30 x 30 mm or 40 x4 0 mm, by 2 mm or 2.5 mm as scheduled or shown on the drawings. Posts shall be of 76 x76 x 1.6 mm square tubing, with fixing brackets and cap tops. All elements shall be hot-dip galvanised after cutting and welding.

6.3.5 Motor Grid Gates

All motor/cattle grid gates shall consists of a concrete floor pit approximately 3 m wide, 1.5 m long and 500 mm deep, with concrete or masonry walls around the sides. The pit is spanned by a grid consisting of steel pipes or mild steel railway supported by the side walls and brick sleeper walls.

At the ends and in the middle of the steel pipe grid there shall be steel constructions to hold the pipes down and to keep them apart at the required distances. The cattle grid shall be built in such a way that runoff water from the road does not flow into the pit. Provision shall be made for rainwater caught by the pit to drain away from the pit.

Cross members shall be one of the following:

a) Mild steel railway with a unit mass, depending on the road width, of between 22 kg/m and 48 kg/m. Second-hand sections may be used; and
b) Steel pipes of 76 mm outside diameter.

6.4 CONSTRUCTION

6.4.1 General

Fencing and barriers shall comply with the Occupational Health and Safety Act, No. 85 of 1993 Construction Regulation 2014 and Construction Regulation 28 when stacking fencing material.

Materials to be stacked in a designated area not causing an obstruction or tripping hazard.

No existing or permanent fences adjacent to the Works shall be damaged.

In general, temporary fences shall be of the same standard or type of fence they temporarily replace during construction, and shall as a minimum, conform to this Specification.

No temporary fence shall be dismantled until after the successful completion, commissioning and acceptance testing, and sign-off of the rehabilitation.

The Contractor must ensure that all gates and fences are protected and maintained and will be responsible for damages which must be done within 24 hours.

6.4.2 Types of Fencing

The following types of fences shall be erected in accordance with the details shown on the drawings:
a) Seven strand stock proof fence at 1.25 metres high;
b) Sixteen strand game proof fencing at 1.83 metres high;
c) Twenty-one strand game proof fencing at 2.43 metres high;
d) High security fencing at 3 metres high;
e) Where existing fences have to be dismantled and re-erected, they shall be re-erected either to the same design as the original or they shall be re-erected to one of the standards specified where relevant. The Contractor shall keep complete records of where fencing has been removed by means of referenced GPS points in order to re-erect at the correct locations on completion of the civil Works. Copies of these records are to be updated regularly and be made available to the Engineer on request; and
f) Contractor’s establishment area fencing 2.4 m high

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SECTION 7
SITE CLEARING

7.1 SCOPE

This Section deals with the clearing, grubbing, removal and stockpiling of topsoil and fertile soil at the areas required for the construction of all the Temporary and Permanent Works. It also includes the removal, relocation and/or disposal of existing structures and services.

7.2 DEFINITIONS

7.2.1 Definitions

a) **"Demolishing"** means the breaking out and down and complete removal and disposal of buildings, sheds, poles, concrete and all and any other objects and structures.
b) **"Fertile Soil"** means at least 500 mm (in cultivated land) and 450 mm (in all other areas) of the profile of soil still present after the "Topsoil" (i.e. OGL minus 300 mm and 150 mm respectively) had been removed or the actual depth of fertile soil available if it is less than these specified values, which will also be regarded as maximum values or as determined during the pre-construction survey.
c) **"OGL"** means the original ground level as surveyed prior to any activities taking place.
d) **"Topsoil"** means at least the top 300 mm (in cultivated lands) and 150 mm (in all other areas) of the soil profile irrespective of the fertility appearance, structure, agricultural potential, fertility and composition of the soil or the actual available depth if it is less than these specified values, which will also be regarded as maximum values or as determined during the pre-construction survey.

7.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

7.3 TOLERANCES

Clearing and grubbing as may be required shall be undertaken within the Site as per the drawings and defined herein for the excavations and structures to be constructed.

7.4 GENERAL

The Works to comply with OHSAct 85 of 1993, the Construction Regulation 27 and the Construction Regulation 2014.

The Contractor shall ensure that the clearance of vegetation is strictly limited to that required to facilitate the execution of the Works within the Site. Any vegetation, particularly trees immediately adjacent to the working area, which do not require removal, shall be protected against damage and maintained.

The Contractor's environmental staff shall monitor the Site clearing activities, with particular focus on heritage resources and graves, as well as protected and/or threatened fauna and flora species. After clearing and grubbing, the Contractor shall remove, stockpile and maintain topsoil and fertile soil for future use, i.e. rehabilitation and re-vegetation.

In order to reduce erosion and pollution of water entering water courses, grubbing of cleared areas shall, in conjunction with the construction of erosion control structures, be undertaken immediately prior to the commencement of construction or borrow activities in the area. The Contractor shall plan and execute his grubbing operation to minimise the time that grubbed areas are exposed before construction activities start.

Seven days prior to the start of work in any area the Contractor shall submit to the Engineer the pre-construction survey specialist report and the Method Statement that shall include inter alia the following:

- The use of herbicides, pesticides and other poisonous substances;
- Clearing and grubbing for the Works;
- Measures for protecting and/or relocating threatened and/or protected fauna and flora from damage during clearing and related construction activities;
- Cutting down of trees and removal of logs to positions agreed with the Engineer so as to enable the landowners to utilise the material; and
- Stripping and stockpiling of topsoil and fertile soil.

In order to manage environmental impacts associated with site clearing, the Method Statement must, as a minimum, include the Management Actions listed in Section 14.3.1 of the Approved EMPr, including:

- Restrict site clearing activities to construction area / domain;
- Clearing of vegetation to be conducted in a phased manner (where possible), with due consideration of the search and rescue activities. Vegetative cover for sensitive areas such as riparian zones is to remain for as long as possible;
- Where possible, clearing by hand is recommended in order to create employment opportunities;
- Maintain barricading around sensitive environmental features;

- Avoid any disturbance to demarcated sensitive environmental features; and
- Suitably experienced personnel (relevant to the potentially affected environmental features) to monitor the clearing activities, with particular focus on heritage resources, as well as protected fauna and flora species.

7.5 SITE CLEARING

7.5.1 Environmental Conditions affecting Site Clearing

Prior to the commencement of site clearing, and in accordance with the approved Environmental Management Programme (EMPr) and Environmental Authorisation, the Contractor shall be responsible for the following:

- Conduct a pre-construction baseline survey of terrestrial ecology (flora and fauna) in order to provide a benchmark against which impacts resulting from construction and operation of the project can be measured;
- A detailed Search, Rescue and Relocation Plan for flora and fauna must be compiled by a Terrestrial Ecologist and reviewed by Cape Nature and submitted to the Department of Forestry, Fisheries and Environment for approval prior to the commencement of construction activities;
- A walk-through of the final pipeline route must be conducted prior to construction in late winter/early spring by a qualified specialist who is highly familiar with the flora and fauna of the region. Should Species of Conservation Concern be encountered, they should be avoided and only if this is completely impossible, then search and rescue should be undertaken by a qualified specialist;
- Should permits for the removal of flora or fauna be required, the Contractor must make such applications to the relevant authorities prior to implementing the necessary removals;
- A monitoring plan shall be developed for faunal species in order to conduct regular walk downs of the area to monitor the trenches for animals that may have fallen in. This plan must be implemented prior and during construction; and
- All plans will need to comply with the requirements of Cape Nature and Nature Conservation Ordinance of the Western Cape Province.

The conditions above are not exhaustive.

7.5.2 Demolition and Removal of Existing Structures

Any existing structures located within the Site, including but not limited to buildings, dams and services, shall only be damaged or demolished and removed with the prior approval of the Engineer, and in accordance with the requirements of any appropriate licenses or approvals.

Material from the demolition of existing structures shall be removed from the work area to a suitable stockpile or disposal site.

7.5.3 Clearing

Clearing of the Site shall consist of the removal of all trees, bushes and shrubs (approximately 300 mm above the natural ground level); rubbish; fences; rubble; rocks; boulders and all other objects and material for construction purposes. During the clearing, basal or grass cover, including fertile soil and topsoil shall be removed or disturbed.

The removal of a certain amount of soil or gravel material below the fertile soil and topsoil may be inherent to or unavoidable during the process of clearing but shall be kept to a minimum.

7.5.4 Grubbing

The stumps of felled and cut trees and shrubs shall be completely removed within the pipeline construction servitude and borrow pit areas to a designated spoil area. Roots having a diameter greater than 20 mm shall be removed to at least 500 mm below foundation level or original ground level, whichever is the lower. Tracked and wheeled mechanised equipment may be used. The Contractor shall carry out clearing, which must then be followed by grubbing.

In the areas of the Permanent Works, any cavities resulting from grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

Grubbing shall include the removal of all rocks and boulders of up to 1 m^3 in size that are exposed on the surface through levelling of the grubbed area.

7.5.5 Removal, Stockpiling and Disposal

The material from clearing and grubbing that cannot be used for mulch or landscaping by the Contractor or firewood by others shall be moved from the work area to a suitable stockpile or disposal site.

7.5.6 Stripping and Stockpiling of Topsoil and Fertile Soil

The Contractor shall strip the topsoil and fertile soil (as indicated below) for subsequent use during rehabilitation. Topsoil and fertile soil shall be stripped from the boundaries of working areas where such material will be impacted by the construction activities. Records of the stripping depth and quantities of topsoil and fertile soil (removed and stockpiled) in each area must be kept for reference during rehabilitation.

Topsoil and fertile soil shall be stockpiled at suitable designated areas within Site. Stockpiles shall not exceed 2 m in height and shall be so placed to occupy minimum width compatible with the natural angle of repose of the material, and measures shall be taken to prevent the material from being spread over too wide a surface.

The stockpiles shall be formed such that no ponding of surface water forms on the surface of the stockpile. The Contractor shall take all necessary precautions to protect and conserve the topsoil and fertile soil from wind and water erosion, contamination and infestation of weeds and alien and invasive plants. This can be achieved through inter alia stormwater and cut off drains, and by establishing temporary vegetation on the stockpiles. If the Contractor fails to conserve topsoil and fertile soil in this Contract, he shall obtain suitable material from other sources, approved by the Engineer, without any additional payment.

Topsoil and fertile soil shall not be buried or rendered in any other way unsuitable for re-use, and precautions shall be taken to prevent unnecessary handling and compaction. Topsoil and fertile soil shall not be subject to a compaction force greater than 1 500 kg/m² and shall not be pushed by a bulldozer for more than 50 m. Trucks may not be driven over the stockpiles, nor shall stockpiles be used as laydown or storage areas, and no stockpiles may be used as loading ramps or topsoil used as blast cover.

7.5.7 Mulching

Branches and twigs, that are smaller than 75 mm diameter and larger than 20 mm diameter, which have been trimmed from trees shall be chipped to a maximum size of 50 mm. All other trimmed material and non-woody vegetation shall be shredded to mulch. Chips and mulch shall be mixed to assist in composting of this material.

Where required, all branches and trunks of trees larger than 75 mm in diameter shall be trimmed off side branches and twigs and cut into logs of 3 m in length and stockpiled at the designated spoil areas or in areas agreed with the land owner or occupier. All other cleared vegetation, except alien vegetation and its seeds, must be mulched, and the mulch used to cover and protect topsoil windrows.

All cleared non-woody vegetation shall be mulched and mixed into the topsoil stockpiles, used as brush-packing (depending on the type of vegetation) or disposed of at an approved disposal site. Burning of cleared vegetation is prohibited in terms of the Atmospheric Pollution Prevention Act (No. 45 of 1965). The burying of cleared vegetation or use as part of backfill or landscape shaping is prohibited unless written approval is obtained from the Engineer.

All shredded and mulched material shall be safely and neatly stockpiled in rows not exceeding 2 m in height, allowing easy access for unloading and re-loading by mechanical means.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 8

DEALING WITH WATER

TCTA MODULAR STANDARDS
SECTION 8
DEALING WITH WATER

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SECTION 8
DEALING WITH WATER

8.1 SCOPE

This Section deals with the requirements for dealing with water including the collection, treatment and discharge of water within and from the Works arising from all natural and artificial sources.

8.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

8.2.1 Definitions

a) **"Sedimentation or Settlement ponds"** are ponds that retain sediment laden water from the Works for a sufficient period for the sediment to settle. These include small scale portable devices used to remove sediment from water.

b) **"Oil separator"** is a trap that separates oil from water and prevents oil from being carried into the environment.

c) **"Slurry trench"** is a trench filled with bentonite or other material to create an impervious barrier.

d) **"Pollution incident"** is any incident that may or has caused contamination of soil or water and may result in significant damage to the natural environment.

e) **"Contaminated water"** means any water contaminated by the Contract activities and relates to work occurring in a Watercourse/Waterbody, or any form of pollutant to surface or underground water.

f) **"Watercourse"** means:
   i) a river or spring;
   ii) a natural channel in which water flows regularly or intermittently;
   iii) a wetland, lake or dam into which, or from which, water flows;
   iv) any collection of water which the Minister of Water and Sanitation may, by notice in the Gazette, declare to be a watercourse; and
   v) a reference to a watercourse includes, where relevant, its bed and banks, up to and including the 1:100 flood line.

g) **"Waterbody"** means a body containing any form of water and includes dams and Wetlands, whether ephemeral or permanent.

h) **"Wetland"** means all areas with waterlogged soils, or soils covered with a shallow layer of water (permanently or seasonally), unique types of soil formed under seasonal or permanent saturation, and distinctive plants adapted to water-saturated soils.

8.2.2 Abbreviations

COD	Chemical Oxygen Demand
EC	Electrical conductivity
EMPr	Environmental Management Programme
EWR	Ecological Water Reserve
NWA	National Water Act
SANAS	South African National Accreditation System
SANS	South African National Standard

8.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014 and Construction Regulation 26 - Water environments.

8.3 DEALING WITH WATER

8.3.1 General

The Contractor shall be responsible for the management and control of water, whether from local water courses, rainwater, seepage, underground springs or any other source or cause.

The Contractor shall take all precautions and properly deal with and dispose of all water to ensure that:

a) The Works are kept sufficiently dry at all times for its proper execution;
b) There is minimum deleterious impact on the environment and adjacent properties;
c) Stormwater runoff as a result of storms is controlled effectively at all areas of the Works;
d) There is minimum damage, inconvenience or interference arising from flood waters;
e) There is compliance with all relevant legislation;
f) All construction activities comply with the requirements of the National Water Act (NWA);
g) Water leakages from pipes or taps are prevented;
h) Stormwater from the Site is managed to avoid environmental contamination and erosion; and
i) Erosion on access roads due to construction traffic is prevented.

To ensure compliance with the above list, the Contractor shall construct sumps, furrows, drains, cofferdams, measuring weirs, settlement ponds, oil separators, slurry trenches, cut-off trenches and any other Temporary Works as may be necessary. The Contractor shall also provide, operate and maintain in sufficient quantity such pumping equipment, well points, pipes, pollution prevention and control structures or equipment, and other measures and equipment as may be necessary, subject to the environmental controls specified in this Section. The Contractor shall establish a dedicated vehicle maintenance area and wash-bay, where suitable stormwater management measures are in place to prevent pollution.

Such measures shall continue for the duration of the Contract, and shall at all times be subject to the review of the Engineer with regard to their sufficiency and the achievement of environmental protection goals.

The Contractor shall minimise the use of water and shall immediately attend to any wastage, in order to rectify the problem and introduce additional measures to prevent its recurrence.

Natural water sources (e.g. springs, streams, open waterbodies) shall not be used for the purposes of personal washing and the washing of equipment or clothing. Similarly, natural water sources may not be used for construction water abstraction unless valid water use licenses in this regard have been issued.

The Contractor shall notify the Engineer immediately of any pollution incidents on Site. Verbal reports must be followed up by a report in writing within 24 hours of the incident.

Upon completion of the Works, all temporary diversions, protective works and dewatering systems shall be removed by the Contractor. Affected areas shall be rehabilitated in line with the requirements of the EMPr and MS47 – Landscaping and Rehabilitation.

8.3.2 Surface and Trench Excavations

Surface works, general and trench excavations shall be protected against the ingress of surface and ground water (e.g. berms and cut-off drains). Where the ingress of water is unavoidable, the Contractor shall ensure that the excavation is free draining and that any water entering the excavation does not endanger its stability or cause erosion of any portion of the Works and without the risk of releasing contaminated water into the environment. The disposal of any water found in the excavation shall comply fully with all relevant legislation, and applicable water quality standards.

The Contractor shall furthermore ensure that no concentration or accumulation of water occurs either within, around or above the area of any open excavation which may affect the safety of the excavation.

The Contractor shall maintain excavations such that ponding of rain water is prevented by suitably sloping surfaces and by the construction of channels and sumps.

Where excavations are not free-draining, the Contractor shall construct sumps and install pumps of adequate capacity to control the water level as required for construction of the Works.

The Contractor shall ensure that in areas where existing pipes / channels / canals carrying water or water containing waste may enter the servitude and pipe excavation, the necessary planning is done during the pre-construction survey and precautions taken to ensure that such water or water containing waste is kept out of the servitude and any excavation, in full compliance with the relevant legislation.

8.3.3 Borrow Pits

Should borrow pits be established / utilized for the project, these shall be continuously protected against the avoidable ingress of surface and rain water runoff, and the Contractor shall construct such temporary cut-off and diversion measures as may be required to divert or control surface water in line with the requirements of Regulation 704 promulgated in terms of the National Water Act (Act 36 of 1998).

The Contractor shall minimise the flow of any surface water or floodwater into borrow areas. Where necessary he shall protect borrow areas by an earth berm or sandbag system to deflect clean surface runoff away from excavations.

The Contractor shall allow for the drainage of all borrow areas.

No residue or substance which causes or is likely to cause pollution of a water resource may be placed in the workings of any borrow pit.

The Contractor shall plan his borrow operations in such a way that the borrow pits above the natural water table are self-draining. Where this is not possible, these borrow pits shall be dewatered by pumping. In gaining materials from borrow areas below the water table, the Contractor shall ensure that disturbed water from within the borrow pit will not be contaminated.

In this regard the requirements of Section 14 – Spoil, Borrow and Excavated Materials are also relevant.

8.3.4 Underground Works

The Contractor shall deal with all water in underground Works whether flowing into the Works from natural water sources or as a result of construction operations. The Contractor shall keep construction areas dry for the duration of his activities in or near Watercourses, Wetlands and Waterbodies. This work shall also be done in accordance with the requirements for Sensitive Areas in Section 4 – Environmental Management.

8.3.4.1 Waterbodies and Watercourses

When working in or near Watercourses and Waterbodies, the Contractor shall take all precautions necessary to prevent contaminated water from construction activities entering the Watercourses and Waterbodies. Contaminated water, which includes water contaminated with silt, soil particles etc., shall be pumped from the construction areas and be dealt with in terms of clauses 8.4.1 and 8.4.2 before it is returned to the Watercourse or Waterbody. For the duration of construction or when a Watercourse or Waterbody is disturbed in any way, the effect on the water in such Watercourse or Waterbody shall be monitored and tested in terms of Clause 8.5.

When working in or near any Watercourse or Waterbody, the Contractor shall be responsible for the following environmental controls and considerations:

a) No work in or near Watercourses shall commence without the Engineer's approval of the requisite method statement;
b) Monitoring of water quality shall be undertaken as per Clause 8.5 for the duration of construction at all point and diffuse source monitoring sites as well as baseline monitoring sites;
c) The Contractor shall programme the execution of the Works such that construction within flowing water is minimised. In this regard, the only work that will be allowed in flowing water shall be the creation of coffer dams, or installation of diversion structures. All diversions shall be in place, water diverted away from, or piped across, the working area and the temporary infrastructure suitably protected against erosion and flooding prior to excavation commencing;
d) Construction equipment, including light vehicles, shall not cross any Watercourse or Waterbody or operate from within the Watercourse channel, unless it is essential to the execution of the Works and after all required permissions have been obtained;
e) When working in flowing water, the Contractor shall ensure that downstream sedimentation is controlled by installing and maintaining the necessary temporary sedimentation barriers, e.g. geo-fabric silt curtains or sedimentation weirs constructed out of suitably secured straw bales. Sedimentation barriers shall be a maximum of 25 m downstream of the construction activities. In all instances these barriers shall be installed prior to the commencement of construction activities in flowing water. However, in cases where the water flow may be such that these measures cannot be maintained, the Contractor shall request the Engineer's approval for other suitable measures to protect the environment;
f) Where practical (depending on scale), temporary diversions shall be lined with 250 µm plastic or geotextile fabric to control the erosive effects of the flow and prevent the migration of fines into the Watercourse. The full cross-section of the temporary diversion shall be lined, and the plastic/ geotextile strips shall extend for a minimum of 2 m beyond the lip of the excavation and shall be anchored using sandbags. Adjacent plastic / geotextile strips shall be overlapped with the upstream section overlaying the downstream section;
g) During the execution of the Works, the Contractor shall take appropriate measures to prevent pollution and contamination of the riverine environment e.g. including ensuring that

construction equipment is well maintained and not leaking oils or fuel, placing of drip trays under pumps, installation of oil absorbent booms across the Watercourse, re-fuelling and servicing equipment outside of the Watercourse area, provision of the requisite hydrocarbon spill kits, provision of litter bins, regular monitoring etc. as indicated in Section 4 – Environmental Management;

h) All construction roads in or adjacent to the riparian zone should be aligned and managed so as to minimise disturbance of the riparian zone and in-stream habitats;
i) Where earthworks are being undertaken in close proximity to any Watercourse or Waterbody, slopes shall be stabilised using sandbags or geotextile to prevent sand and rock from entering the water;
j) The mitigation methods used must be audited during construction, and monitored for a period thereafter, until full rehabilitation is assured and stability demonstrated;
k) Include mitigation measures identified as part of environmental sensitivity walk down survey;
l) Appropriate rehabilitation and re-vegetation measures for riverbanks, as outlined in the EMPr, shall be implemented timeously. In this regard, the banks shall be appropriately and incrementally stabilised as soon as construction allows;
m) For natural Watercourses, the original geometry, topography and geomorphology in both cross-sectional and longitudinal profile should be reinstated to match the conditions that prevailed prior to construction, both upstream and downstream of river crossings;
n) Construction areas shall be demarcated and watercourses marked as “restricted” in order to prevent the unnecessary impacts to these systems;
o) Storm water channels and preferential flow paths shall be filled with aggregate and/or logs (branches included) to dissipate and slow flows limiting erosion; and
p) Other requirements in the EMPr for additional measures to manage impacts to watercourses, including:
    - Section 10.5 – Water Management;
    - Section 10.7 – Waste Management;
    - Section 10.8 – Hazardous Substance Management; and
    - Section 10.13 – Rehabilitation Management.

With regards to flow, the following shall be ensured:

a) During the excavation within watercourses, flows shall be diverted around active work areas where required. Water diversion must be temporary and re-directed flow must not be diverted towards any stream banks that could cause erosion;
b) Minimise construction footprint where the construction activities take place in-stream or in close proximity to watercourses;
c) Prevent erosion on steep slopes;
d) Minimise influence to downstream flow regime when diverting and impeding flow for cofferdams, temporary river crossings or for any other purposes;
e) Do not hinder flow in natural drainage lines; and
f) Construction activities not to adversely interfere with downstream water users.

With regards to river morphology, the following shall be ensured:

a) Reinstate (shaping) and rehabilitate (riparian vegetation) affected areas in riparian zone and watercourse channel. Structure and function to be returned to pre-construction state;
b) Install suitable buttressing to prevent future erosion, if required;
c) No illegal crossing of watercourses with construction equipment. Suitable temporary river crossing to be built. Select most appropriate crossing point based on geotechnical conditions, sensitivity of riparian habitat (e.g. protected trees, large trees that afford bank stabilisation) and instream habitat, depending on technical feasibility. Crossing points to be approved by Engineer;
d) No construction facilities (including storage areas, containers, chemical toilets, etc.) to be located within natural drainage lines; and

A buffer zone of 30 m from the edge of a delineated riparian zone shall be maintained between construction activities such as mixing areas, stockpiles and laydown yards.

With regards to water quality, the following shall be ensured:
a) Undertake water quality monitoring and biomonitoring in the affected watercourses;
b) All diffuse pollution sources to be managed to prevent pollution of the watercourses in the project area;
c) Where necessary, install instream silt traps during construction within the watercourse channel and along the riparian habitat. Instream silt traps are to be maintained and serviced on a regular basis. The style of silt trap will depend on materials used and the water movement patterns. If silt traps are not deemed feasible, other suitable measures need to be taken to limit unnaturally high sediment volumes in the watercourses;
d) Implement suitable stormwater measures during construction to manage ingress of runoff into watercourses;
e) No wastewater to be released to natural drainage lines;
f) Ensure proper storage of material (including fuel, paint) that could cause water pollution;
g) Ensure proper storage and careful handling of hazardous substances with spill prevention materials at hand; and
h) Reduce sediment loads in water from dewatering operations. All dewatering should be done through temporary sediment traps (e.g. straw bales, geotextile socks, etc.). These are to be serviced regularly and removed when no longer in use. Materials can be re-used.

8.3.4.2 Wetland Crossings

Where the pipeline crosses a Wetland, the various soil layers shall be removed and stockpiled separately. Following the laying of the pipeline and the placing of bedding and backfill materials, all material from the various soil layers shall be returned in the reverse order to which they were removed (refer to Figures 8/1 and 8/2). Care shall be taken to ensure that the various soil horizons

and impervious layers that support the Wetland area are reinstated and linked to those in the undisturbed soil.

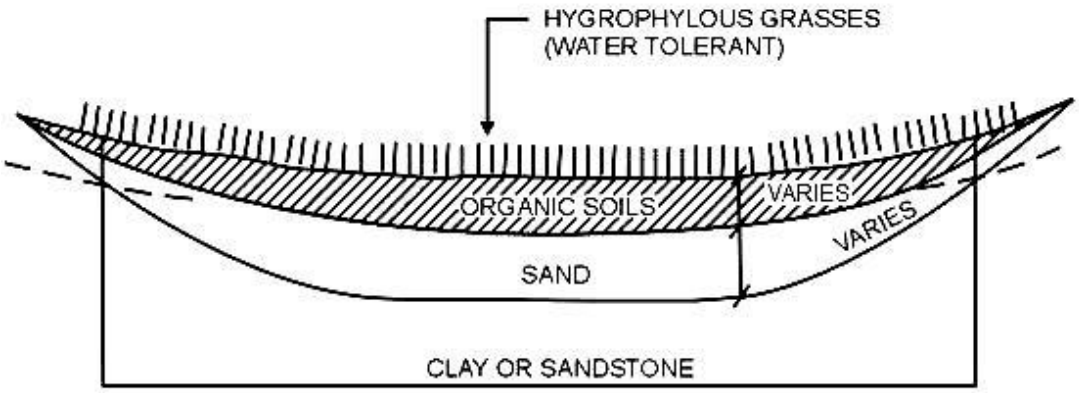


FIGURE 8/1
TYPICAL SECTION THROUGH WETLAND

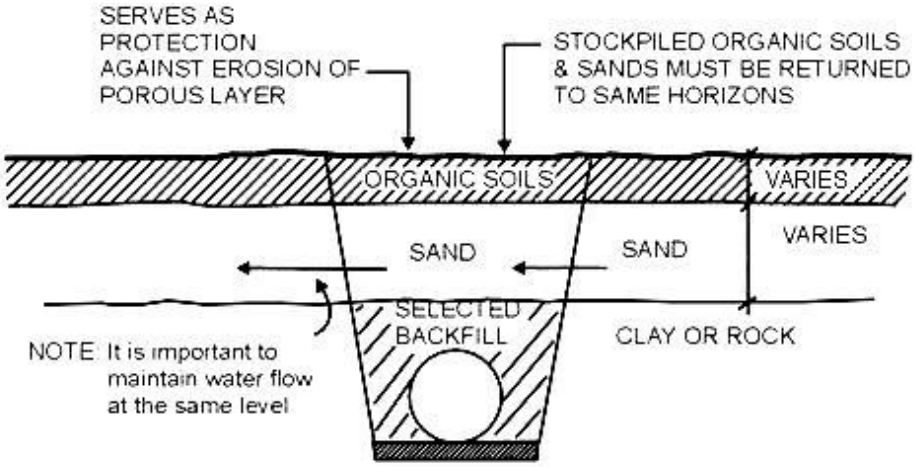


FIGURE 8/2
TYPICAL BACKFILL OF PIPE TRENCH THROUGH WETLAND

8.4 MANAGEMENT OF WATER

8.4.1 Pumping

Pumps shall be placed over a drip tray in order to contain fuel spills and leaks. The Contractor shall take all reasonable precautions to prevent spillage during the refuelling and maintenance of these pumps.

The Contractor shall ensure that none of the water pumped during dewatering activities, is released into the environment without passing through the requisite sediment and oil traps to the Engineer's approval. Cognisance shall also be taken of the controls specified under Clause 8.3, 8.4 and 8.5.

8.4.2 Management of Polluted Runoff

Pollution could result from the release, accidental or otherwise, of contaminated runoff from construction establishment and batching areas, discharge of contaminated water, chemicals, oils, fuels, sewage, runoff from stockpiles, solid waste, litter, etc. Accordingly, the Contractor shall take all precautions necessary to properly manage and dispose of runoff from the Works, and thereby ensure that any deleterious impact on the environment and adjacent properties is prevented or minimised.

Such precautions shall include, but are not limited to:

a) Appropriate pollution control facilities necessary to prevent discharge of water containing polluting matter or suspended materials into Watercourses or Waterbodies shall be designed and implemented;
b) Runoff from concrete batching areas shall be strictly controlled, and contaminated water shall be collected, stored and either treated or disposed of off-site, at a location approved by the Engineer;
c) Runoff from vehicle wash bays, workshops and diesel and fuel tank areas shall pass through oil traps. The oil sludge thus collected shall be removed and disposed of at an approved sludge disposal facility. In the design of these oil traps consideration shall also be given to the removal of degreasing agents, emulsifiers and other substances that do not necessary float on water;
d) All spillage of oil onto concrete surfaces and floors in workshop areas shall be controlled by the use of an approved absorbent material and spill kit, with a view to reduce the oil load entering the oil traps. Used absorbents shall be disposed of appropriately; and
e) Water collected during the dewatering of pipe trenches shall be pumped to sedimentation ponds complying with the requirements of Clause 8.4.4.

Water that has been contaminated only with suspended solids, like soils and silt from disturbed areas may be released into Watercourses or Waterbodies only after all suspended solids have been removed from such water by settling out these solids in settlement ponds (refer to Clause 8.4.4). The release of settled water back into the environment shall be subject to the Engineers approval. Such settled water may be used for dust suppression on haul roads.

The Contractor shall notify the Engineer immediately of any pollution incident on Site. A verbal report shall be followed up by a report, which shall be provided within 24 hours of the incident.

8.4.3 Quality of Water Discharged from the Works

All wastewater discharged from the Works shall comply with the requirements of Clause 8.5.2 and the legal requirements associated with the NWA, including the General Authorisation that specifically deals with S21 (f) and (g) water uses before it is discharged into any natural Watercourses, Waterbody or land. Wastewater discharges to form part of water monitoring programme. Natural stormwater run-off not contaminated by construction operations and clean water can be discharged directly to natural Watercourses and Waterbodies. Stormwater runoff from workshops, vehicle

maintenance area, wash-bay and other potential pollution sources shall be collected and treated in hydrocarbon separation pits/tanks before discharged to drains and waterways.

8.4.4 Sedimentation Ponds

The Contractor shall construct, operate and maintain for the duration of the of the Contract, sedimentation ponds with sufficient capacity for their purpose, and with suitable oil traps at each point where contaminated water may be discharged from the Works, including at batching areas, vehicles wash areas. Temporary sedimentation ponds will likely be used along the Works in dewatering applications and at the Contractor's facilities. The Contractor shall submit Method Statements and obtain the Engineer's approval to all proposals in connection with sedimentation ponds prior to the construction of such ponds. The Engineer shall be informed of the proposed size, location, layout and operation of the sedimentation ponds. The material that accumulates within the sedimentation ponds shall be disposed of in a suitable manner. The Contractor shall submit Method Statements for the Engineer's approval before commencing with the disposal of accumulated material.

The Contractor shall ensure that sedimentation ponds are located above the floodplain and outside of riparian vegetation zones of Watercourses or Waterbodies, and that the area is rehabilitated on the cessation of operation of the pond. Sedimentation ponds shall be constructed using suitable materials and shall be watertight, using a suitable liner. The ponds shall be sub-divided to enable alternative sections to be cleaned while other sections are in operation. Temporary settlement ponds may be a combination of sections of the excavated trench and silt traps as per Clause 8.3.5.1.

All natural groundwater and stormwater must be prevented from flowing into sedimentation ponds, and must be diverted around the ponds to ensure that accumulated sludge is not washed into natural Watercourses and Waterbodies by stormwater.

All facilities constructed for the management of dirty and clean stormwater at borrow pits shall comply with the requirements of Regulation 704, promulgated in terms of the National Water Act (Act 36 of 1998).

8.4.5 Pipeline Testing

The quality of water used for the hydrostatic testing of the pipeline shall be monitored prior to its release into any Watercourse or Waterbody and shall comply with the requirements of Clause 8.5.

During draining and scour operations, water shall be released in a controlled manner avoiding erosion. In cases where permanent structures are used for draining the pipeline, all the requisite erosion protection measures shall be in place prior to releasing the water.

8.4.6 Water Abstraction

The procurement and discharge of water required for construction and hydrostatic testing shall comply with the requirements of the National Water Act (No 36 of 1998) and related regulations.

Where authorisation has been granted to abstract water from a Watercourse or Waterbody, the Contractor shall ensure the following:

a) A vehicle abstracting water does not enter or cross the Watercourse and does not operate from within the Watercourse;
b) No damage occurs to the Watercourse bed or banks and that the abstraction of water does not entail stream diversion activities;
c) All reasonable measures to limit pollution or sedimentation of the downstream Watercourse are implemented e.g. construction equipment is well maintained, use of drip trays, provision of bins, monitoring of personnel and activities; and
d) The Contractor's Equipment, such as pumps and associated equipment shall be appropriately bunded and located above the 1:50 year flood level.

ANNEXURE 8/1

VARIABLE	REQUIRED EFFLUENT STANDARD
Arsenic (as As)	Not to exceed 0.1 mg/ℓ
Boron (as B)	Not to exceed 0.5 mg/ℓ
Cadmium (as Cd)	Not to exceed 0.05 mg/ℓ
COD	Not to exceed 5 mg/ℓ
Colour, odour, taste	Free of any substance in a concentration capable of producing any colour, odour
Conductivity	Not to be increased by more than 15% above influent, and shall not exceed 250 mS/m
Copper (as Cu)	Not to exceed 0.02 mg/ℓ
Cyanide (as Cn)	Not to exceed 0.5 mg/ℓ
Dissolved oxygen	At least 75% saturation
Feacal coliforms Thermotolerant (faecal) coliform bacteria	No *E. coli* (0/100 mℓ) or No Thermotolerant (faecal) coliform bacteria (0/100 mℓ)
Fluoride (as F)	Not to exceed 1.0 mg/ℓ
Free and saline ammonia (as N)	Not to exceed 1.0 mg/ℓ
Lead (as Pb)	Not to exceed 0.1 mg/ℓ
Manganese (as Mn)	Not to exceed 0.1 mg/ℓ
Mercury (as Hg)	Not to exceed 0.02 mg/ℓ
Nitrate (as $N0_3$)	Not to exceed 1.5 mg/ℓ
Nitrite	Not to exceed 1.0 mg/ℓ
pH	Between 5,5 and 7,5
Phenolic compound (as phenol)	Not to exceed 0.01 mg/ℓ
Phosphate (as $P0_4$)	Not to exceed 1.0 mg/ℓ
Residual Chlorine (as Cl)	Non residual chlorine
Selenium (as Se)	Not to exceed 0.05 mg/ℓ
Soap, oil, grease	No soap, oil or grease
Sodium	Not to be increased by more than 50 mg/ℓ above influent
Sulphides (as S)	Not to exceed 0.05 mg/ℓ
Suspended solids	Not to exceed 10 mg/ℓ
Temperature	In addition the effect of water discharged into Watercourses shall not raise the water within the Watercourse at a point 500 m downstream of the point of discharge by more than 2^{o}C above the temperature of the water 500 m upstream of the Works
Total Chromium (as Cr)	Not to exceed 0.05 mg/ℓ
Zinc (as Zn)	Not to exceed 0.03 mg/ℓ

ANNEXURE 8/2

VARIABLE	
The following measurements shall be taken in the flowing part of a stream:	
i)	pH (pH units);
ii)	Temperature (ºC);
iii)	Colour and odour;
iv)	Turbidity;
v)	Electrical conductivity (EC) (mS/m); and
vi)	Dissolved Oxygen (mg/l and % saturation).

The instruments should have a range and accuracy of 0 to 20 mg/l ±0.2 mg/l for dissolved oxygen, -5 to 40°C ±0.2°C for temperature, 0 to 14 units ±0.2 units for pH, and 0 – 2000 mS/m ±0.1 mS/m (0.001 mS/cm).

ANNEXURE 8/3

BASELINE MONITORING SITES
River / Stream crossings near:
Note: To be updated when baseline studies are completed

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TCTA MODULAR STANDARDS

SECTION 9

BULK SURFACE EXCAVATIONS AND TRENCHING

TCTA MODULAR STANDARDS
SECTION 9
BULK SURFACE EXCAVATIONS AND TRENCHING

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SECTION 9
BULK SURFACE EXCAVATIONS AND TRENCHING

9.1 SCOPE

This Section deals with bulk surface excavations that are required for the construction of the Works as well as trench excavations that are required for pipelines, culverts, electrical conductors or other components of the Works.

Borrow areas and other excavations that are required solely to provide material for construction or for the provision of bedding for pipelines or for the Contractor's requirements etc., are covered in Section 14 – Spoil, Borrow and Excavated Materials.

9.2 DEFINITIONS, ABREVIATIONS AND REFERENCES

9.2.1 Definitions

a) **"Battering"** means to form the face or side or wall of an excavation to an angle, usually less than the natural angle of repose, to prevent earth slippage.

b) **"Bulk excavation"** shall be excavation, for the Permanent Works, which by virtue of their size and extent can only be efficiently excavated by large construction equipment such as bulldozers, motor graders, scrapers, excavators, etc.

c) **"Formation"** means a surface on which earthworks operations, or a stage of operations, have been completed.

d) **"Foundation"** means that part of the ground on which a structure will be supported.

e) **"Hard excavation in unrestricted bulk surface excavations"** shall be excavation in solid material which cannot be efficiently loosened and excavated by means of a back-acting excavator in mechanically sound condition, fitted with a standard length boom and of flywheel power exceeding 0.10 kW per mm of tined bucket bite width, or a 35 tonne bulldozer (Minimum 220 kW), in mechanically sound condition with a single tine ripper. These formations shall necessitate the use of explosives or drilling, wedging and splitting.

f) **"Hard excavation in restricted or trench excavations"** shall be excavation in solid material which cannot be efficiently loosened and excavated by means of a 35 tonne back-acting excavator in sound mechanical condition, applying a 1 m wide rock bucket with a tip radius not exceeding 1.85 m with maximum 3 tips. The specified curl force and stick crowd force on the bucket edge should at least be 220 kN and 200 kN respectively. This formation shall necessitate the use of explosives or drilling, wedging and splitting.

g) **"Restricted excavation"** means an excavation restricted in area or width as to preclude the removal of the material by means of a bulldozer.

h) **"Soft excavation"** in restricted or trench excavations and unrestricted bulk surface excavations shall be excavation in all materials not requiring blasting or mechanical breaking.

i) **"Spoil"** means excavated material which is unsuitable for use in the Works or material which is surplus to the requirements of the Works.

j) **"Trench excavation"** shall be excavation for pipelines, culverts, electrical conductors or other items which requires the excavation of a trench for the installation thereof.

9.2.2 Abbreviations

AASHTO: American Association of State Highway and Transportation Officials
BS: British Standard
MPa: Megapascal
SANS: South African National Standard
SANAS: South African National Accreditation System

9.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

9.3 GENERAL REQUIREMENTS

a) All excavation work shall be subject to the requirements of the Occupational Health and Safety Act (Act 85 of 1993 and amendments) and Construction Regulation 2014. The Contractor shall comply with Construction Regulation 13 - Excavations when excavating, barricading and shoring.

b) Materials, equipment or other loads shall be kept at a safe distance from excavations to avoid collapsing of the sides of excavations.

c) The Contractor shall implement measures to prevent material falling into excavations, causing damage to the Works or injury to persons.

d) Suitable barricading shall be erected around excavations with warning signage (for people) to prevent access by unauthorised persons and also animals.

e) The Contractor shall inspect open trenches to ensure that animals have not become trapped. Such animals will be safely removed and released, where possible. Special measures for handling of venomous snakes shall be available to ensure safe removal.

f) Where an excavation for pipes or services crosses a public or private road, the excavation and installation of the pipe shall be conducted to provide access to at least one lane of traffic. Suitable traffic control measures shall be maintained. Suitable pedestrian access shall also be provided

g) Storm water shall be accommodated without causing ponding, erosion or flooding.

h) The Contractor shall ensure that excavations are kept free of surface water inflow and ground water infiltration shall be controlled, to prevent floating of pipelines and structures. Runoff shall be diverted away from excavations.

i) The Contractor shall make effort to identify the position of existing underground services and shall take precaution not to damage such existing services during excavation for the Works.

j) The Contractor shall make adequate provision for subsidence of backfilled areas.

9.4 EXCAVATION FOR THE WORKS

9.4.1 Open Trench Restrictions

Trench excavation shall proceed progressively from each pipe laying working head and the opening of trenches at various points along the pipeline route will not be permitted without approval of the Engineer.

Trench excavations shall be continuous and in accordance with the following table, unless otherwise approved by the Engineer:

TABLE 9/1
MAXIMUM LENGTH OF OPEN TRENCH

NUMBER OF PIPES LAID PER DAY (Note 1)	PRODUCTION RATE (Note 2)	MAXIMUM LENGTH OF OPEN TRENCH (Note 3)
3	54 m – 57 m / working day	400 m
4	72 m – 76 m / working day	550 m
5	90 m – 95 m / working day	700 m

Notes:

1. Pipe lengths vary between 18 m and 19 m.
2. Average rate of progress of the train of sequential pipe installation/construction processes.
3. Length of open trench measured ahead of Selected Fill Blanket.

The maximum lengths of open trench in Table 9/1 shall be reduced if required by the applicable policies of insurance.

Where rock excavation is required, the Contractor may be permitted by the Engineer to use special rock excavating teams further ahead of the main excavating team.

9.4.2 Trench Widths

Trenches for pipes shall be excavated to allow the pipes to be properly laid to line and level, bedded, jointed, inspected and tested.

The width shall be in accordance with Table 9/2.

TABLE 9/2
MINIMUM TRENCH WIDTHS FOR PIPE TRENCH CONDITIONS

NOMINAL PIPE DIAMETER (D) (MILLIMETRES)	MINIMUM OVERALL WIDTH (W) OF TRENCH (MILLIMETRES)
D ≤ 600	D + 600
600 < D ≤ 900,	D + 800
900 < D ≤ 1 200	D + 1000
1200 < D ≤ 1800	D + 1 200
D > 1 800	D + 1 400

Notes:

1. The widths refer to trenches containing a single pipeline.
2. Widths of trenches shall be maintained at the base of the trench and the laid pipeline shall be located centrally in the trench to enable selected fill to be effectively compacted below the lower half of the pipe on both sides of the pipe.

9.4.3 Trench Depths

Trench depths shall be maintained for the full width and length of the trench and all stones, rocks or other projections trimmed accordingly.

Where trench bottoms are waterlogged, the trench depth can increased to accommodate stabilisation layers of backfilling.

9.4.4 Preparation of Trench Bottom

a) Where the trench excavation is in soft material, and the bottom of the trench is in sound material, all loose and disturbed material and excavation debris shall be removed and disposed of.

b) Where the trench excavation is in soft material, and the bottom of the trench has been loosened during excavation, it shall be compacted to 90% of Modified AASHTO maximum dry density prior to bedding and pipe laying.

c) Where the trench excavation is in hard material and blasting was required, all loose rock and blast debris shall be removed and disposed of.

d) Where the trench bottom is too soft, waterlogged, unstable, to permit placement and compaction of bedding material to specifications, the trench bottom shall be excavated to a depth below the underside of the pipe and specials for the full width and length of trench affected to accommodate the following trench bottom stabilising layers:

   i) 300 mm thick compacted 19 mm crushed stone enclosed within non-woven, needle punched, continues filament polyester geotextile (Bidim Grade A5 or equivalent) over the full width of the trench and with a minimum overlap of the geotextile of 1000 mm; plus where required the following layer underneath layer i);

ii) 500 mm thick well graded compacted dump rock enclosed within high strength composite (woven or un-woven) geotextile with high modulus characteristics for reinforcement and drainage applications (Rock Grip PC 100/100 or equivalent) over the full width of the trench and with a minimum overlap of the geotextile of 1000 mm; and

iii) The pipe bed material shall be placed on top of layer i).

The necessity for layer i), or layers i) plus ii) will depend on the geotechnical conditions.

9.4.5 Method Statements

Prior to commencement of excavations, the Contractor shall submit Method Statements for the different types of excavation to the Engineer for review.

The Method Statements shall include details of the equipment he proposes to use, control methods to be used (such as batter boards, etc.), proposed measures for the control of water and the sequence and program of his operation, undertaking of work in normal and reduced construction servitudes, how access across the servitude will be facilitated, and how Occupational Health and Safety (OHS) requirements will be enforced, etc.

9.4.6 Protection of Existing Services

Where trenches pass near or across other services, the Contractor shall take adequate precaution against damaging such services. These services shall be properly supported in the trench until backfilling is complete and the backfilling shall be thoroughly compacted under and around such services.

The Contractor shall ascertain whether any existing services exist within the relevant section of the Site. The Contractor shall complete an investigation well in advance of the start of construction work in the said section and shall submit a report as soon as possible to the Engineer including the necessary arrangements by the Contractor for the protection, removal or diversion of the services before any construction work commences.

The Contractor will be held responsible for any damage to services. In the event of a service being damaged, the Contractor shall immediately notify the authority or owner concerned as well as the Engineer. The Contractor shall not repair any such service without the approval of the owner of the service or the relevant service authority, except for if it is an emergency repair for health and safety reasons.

Where the authority or owner concerned elects to carry out any alterations or protective measures, the Contractor shall co-operate with and allow such authority reasonable access and sufficient space and time to carry out the required work.

Where existing services are shown on drawings, based on the information available, the Contractor shall verify the information of all services and all other obstacles and existing works on the Site.

The Contractor shall not use mechanical equipment to excavate within 3 m of the estimated position of any service and shall, if necessary, expose the service by means of hand excavation carried out under proper supervision. The Contractor shall backfill such excavations with suitable material to minimum 90% Modified AASHTO compaction density.

9.4.7 Disposal of Surplus Excavated Material

All surplus excavated material not required for backfilling or unsuitable for re-use and rehabilitation shall be disposed of in designated approved spoil areas, in accordance with the requirements of Section 14 – Spoil, Borrow and Excavated Materials. In the event that borrow and spoil areas are not available, surplus excavated material shall be disposed of at licenced waste disposal sites.

9.4.8 Excavation in Rock

The Contractor's work shall be planned and programmed to minimise excavation by blasting adjacent to existing structures or services and previously constructed parts of the Works to prevent damaging thereto. Where it would be impracticable to avoid damage to adjoining works if explosives are used, the Contractor shall excavate by line drilling as specified in Section 12 - Blasting, using a hydraulic breaker, barring and wedging, chemical blasting or other suitable non-explosive methods.

Rock wedges on rock slopes which are not removed shall be anchored to sound rock.

Over-excavation shall be filled with concrete, or soilcrete or other suitable methods.

9.4.9 Slurry Trenches / Curtain Walls

Surface excavations could include excavations in permeable alluvial deposits below the water table and will require sealing off prior to excavations.

The Contractor shall design appropriate water barriers best suited to his method of construction and shall provide a Method Statement dealing with all aspects of achieving an effective seal in the alluviums to enable workable conditions for excavation and construction.

The final and actual foundation level or hard excavation level must be surveyed.

9.4.10 Tolerances

The tolerances on the completed excavation after clearing of the excavation faces shall be as follows:

+ 50 mm, - 50 mm	in level;
+100 mm, -100 mm	in plan on the excavated surface as an average; and
+ 500 mm, -500 mm	in plan locally.

Rock surfaces to be covered with concrete shall be excavated to the specified lines, levels and dimensions with the following local tolerances:

+ 0 mm, - 250 mm	in level; and
+ 250 mm, - 0 mm	in the horizontal direction measured from the structure towards the rock face.

9.5 PREPARATION AND INSPECTION OF FOUNDATIONS

9.5.1 Foundations for Concrete Structures

9.5.1.1 Preparation of Foundations on Rock

Rock surfaces to receive concrete shall be free of all dust, mud, loose or fractured material and other debris. Fissures shall be cleaned out and treated accordingly. The surfaces shall be washed completely clean using air or water jets immediately prior to placing concrete, cement mortar or sprayed concrete. The Contractor shall clean a trial part of the foundation in advance of the remainder for inspection.

Where rock surfaces reach high temperatures under the influence of the sun, washing shall be carried out at night or in the early morning to avoid fracturing due to thermal shock.

9.5.1.2 Foundations on Materials other than Rock

Any loose or disturbed material shall be removed. The top 300 mm of in-situ material shall be compacted to a minimum of 90% of Modified AASHTO density. Disturbed surfaces shall be recompacted.

Where the in-situ material does not provide a suitable foundation, the Contractor shall replace the unsuitable material with gravel or other suitable material to suitable depths. The replacement fill shall be compacted in layers not exceeding 150 mm in depth to a minimum of 90% of Modified AASHTO density.

9.5.2 Foundations for General Earthworks, Embankments and Terracing

9.5.2.1 General

Cross-sections of the original ground lines shall be surveyed before work commences. Any foundation material occurring within the footprint of where the fill and/or selected fill is to be placed, shall be treated by one or more of the following methods:

a) Draining of foundations;
b) Pioneer layer;
c) Removal of unsuitable material;
d) In-situ treatment of foundations; and

e) Preparation and compaction of foundations.

9.5.2.2 Draining of Foundations

Any water-logged foundation, such as, but not limited to, saturated material overlying less pervious strata, shall first be drained by the installation of all permanent surface or subsoil drainage, before any other construction is started on these sections.

9.5.2.3 Pioneer Layer

Where fill is to be constructed across water-logged or soft ground that displays excessive movement under normal compaction equipment and haulage trucks, thereby precluding the effective compaction of the bottom fill layers, a pioneer layer shall be constructed on the unstable ground. This layer shall be constructed by dumping, spreading and compacting successive loads of suitable coarse material in a uniform layer of a thickness just sufficient to provide a stable working platform for the construction of further fill layers to specifications.

Where required, synthetic fibre filter material, with or without protection or drainage layers, shall be used in conjunction with or in place of a pioneer layer.

9.5.2.4 Removal of Unsuitable Material

Any foundation material that is too wet or of a quality that would be detrimental to the performance of the completed fill, shall be removed to the required widths and depths and be disposed or reused. The excavated spaces shall then be backfilled, treated and compacted with suitable imported fill material.

9.5.2.5 In-situ Treatment of Rock Foundations

The foundation shall be treated in-situ by breaking up undesirable formations of hard or rocky materials in order to achieve a uniform standard of compaction or to improve drainage.

Treatment in-situ shall consist of ripping or blasting the foundation to the required depths.

After ripping or blasting, the material shall be processed as follows:

The material shall be sized by rolling or grid rolling until the maximum dimension of any clod or spall is not more than two-thirds of the thickness of the layer after compaction. The material shall then be compacted to a percentage of Mod AASHTO maximum dry density, as specified by the designer. After blasting, the material shall be processed and compacted as for rockfill.

9.5.2.6 Preparation and Compaction of Foundations

Any foundation material which is classified as suitable for use in-situ, save that it fails to meet the requirements for density, shall be scarified to a depth of 150 mm, watered (if required) and compacted to the required percentage of Mod AASHTO maximum dry density.

Where any additional material has to be imported to obtain the required levels and layer thickness, the foundation material shall be scarified, the imported material placed, and this combined material mixed and compacted to the specified depth of the layer.

9.5.3 Inspection of Foundations

Before any blinding, concrete, bedding material or fill is placed, and when the Contractor considers that a foundation is ready for construction of any part of the Works to commence, the Contractor shall notify the Engineer to inspect the foundations.

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SECTION 10

PIPE JACKING

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SECTION 10
PIPE JACKING

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SECTION 10
PIPE JACKING

10.1 SCOPE OF WORK

This Section covers the manufacturing and installation by jacking of concrete sleeve pipes under infrastructure such as busy roads, railways, canals, rivers etc., without disturbing the activities associated with such infrastructure.

10.2 DEFINITIONS AND REFERENCES

10.2.1 Definitions

For the purposes of this Section the following definitions shall apply:

a) **"Annulus"** is the space between the internal diameter of the jacked sleeve pipe and the outer diameter of the installed service pipe.
b) **"Jacking"** means the action of pushing a sleeve pipeline into position.
c) **"Jacking pipe"** is a reinforced concrete pipe designed specifically for the jacking application. Commercially available jacking pipes complying with SANS 677 can be used.
d) **"Lead pipe"** means a pipe that has a rebated end over which the trailing end of the shield is fitted and that is intended to be the first pipe to be used in the jacking process.

10.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

10.3 LEGAL REQUIREMENTS AND RESPONSIBILITIES

The Employer will arrange wayleaves and clarify conceptual design aspects with the relevant authorities.

The Contractor shall comply with the relevant wayleave requirements and all statutory controls and regulations.

The Contractor shall provide, erect and maintain all the required safety notices in accordance with the SANCOT standard pictograms published in SANS 1186 or similar approved safety notices.

10.4 MATERIALS

The permanent jacking elements shall be reinforced concrete pipes (sleeve pipes), complying with the requirements of SANS 677. It shall have a minimum load designation (class) of 100D with an ogee type joint shape.

Sleeve pipes shall be delivered to site accompanied by its factory quality control pack to confirm compliance with the relevant requirements of SANS 677. The unique number of each pipe, the pipe type, diameter and class shall be clearly visible on the inside of the pipe.

10.5 EQUIPMENT

The Contractor shall provide adequate lighting and ventilation in the underground Works during construction.

The Contractor shall take gas and dust concentration (air quality) readings to measure the presence of noxious or other harmful gasses or dust and to ensure safe working conditions at all times.

The Contractor shall comply with General Safety Regulation 5 - Confined spaces when working underground. All the required safety equipment, rescue equipment, testing equipment and personal protective equipment shall be made available to all employees. All employees that will be part of underground works to have a valid certificate certifying them to enter confined spaces with a certificate of medical fitness.

10.6 CONSTRUCTION

10.6.1 Method Statement

The Contractor shall submit specifications, working drawings and other details to demonstrate methods of installation of pipe jacking, including temporary support, for the crossing of road, rail tracks or other infrastructure at least 14 days before pipe jacking commences.

The Contractor shall comply with Construction Regulation 9 - Risk assessment to identify any potential hazards before commencing with pipe jacking and with Electrical Machinery Regulations when working in an area with overhead and underground cables in proximity.

10.6.2 Recording of Movements

Before commencing pipe jacking work, the Contractor shall inspect the infrastructure in detail, record its condition and levels, and submit a copy of such record to the Engineer. The record shall include at least a detailed level survey and a photographic record with date reference.

The Contractor shall also take measurements and photos after the pipe jacking and record any change in line or level of the road, rail track or other infrastructure traversed. A copy of such record shall be made available to the Engineer immediately after the measurements have been recorded.

The Contractor shall measure levels on the surface directly over the jacking line and for a distance of at least 5 m on each side of the jacking line. Levels shall also be measured in the invert of side stormwater drains or other surface infrastructure.

In order to facilitate control of the measuring of levels, also at later stages, the exact position of each spot height shall be identified and discreetly marked before the levels are measured.

After completion of the pipe jacking, the Contractor shall re-measure the levels in the same positions as before, and shall submit to the Engineer the records of levels taken before and after jacking.

If, within the Contract Period, including the Defects Notification Period, the road or railway or other infrastructure shows any sign of settlement in the vicinity of the jacked pipe, the Contractor shall re-measure levels on the Site.

The Contractor shall be held responsible for the rectification, to the satisfaction of the infrastructure authority and the Engineer, of any deformation or other defects that occurred in the vicinity of the jacked pipe.

10.6.3 Temporary Supports

The Contractor shall provide temporary support where necessary to carry road and rail traffic, and to prevent horizontal or vertical movement and misalignment. This shall be done in accordance with the requirements of the relevant authorities.

The Contractor shall comply with Construction Regulation 12 - Temporary works.

10.6.4 Restriction on Blasting

No blasting shall be carried out without the prior written permission by the relevant authority.

10.6.5 Excavation

The Contractor shall comply with Construction Regulation 13 - Excavations.

The Contractor is responsible to identify underground services or structures that could be affected by the pipe jacking. This must be done far in advance of the pipe jacking excavation to allow sufficient time for protecting or deviation of these services or move the position of the pipe jacking where feasible.

Excavation shall be such that overbreak is kept to a minimum. No material shall be removed in advance of the leading pipe edge, where the leading edge is in unstable or loose material. If the

material at the face starts to slip/collapse, the excavation shall be stopped immediately and the Contractor shall take action to stabilise the material before excavation is resumed.

The Contractor shall implement measures to ensure that the excavation face does not collapse that will endanger persons or cause subsidence and damage to infrastructure.
Should any cavity occur around the outside of a pipe during the jacking process, such cavity shall be immediately supported and filled with suitable grout through holes drilled in the pipe walls.
Any subsidence occurring above the jacked pipe and arising from any cause related to these jacking operations shall be repaired immediately.

The Contractor shall adequately deal with and dispose of water to ensure that the Works are kept sufficiently dry for proper execution.

The Contractor shall provide adequate protection against flooding and damage by storm water or ground water seepage.

For this purpose he shall provide, operate and maintain such pumping equipment, well points, pipes and other equipment as may be necessary to minimise damage, inconvenience or interference with the Works or other infrastructure.

10.6.6 Grouting

When the jacked sleeves are in its final position a sand/cement grout shall be injected to fill all voids between the sleeve and the surrounding material. The grout shall have strength equal to or better than a grout consisting of one part cement and four parts sand and shall have a slump of minimum 120 mm, unless specified otherwise by the designer. The volume of grout injected shall be recorded for each pipe jacking.

Where specified on the drawings, brick end walls shall be constructed and a sand/cement grout shall be injected to fill the annulus between the service pipe and the internal wall of the jacked sleeve pipe. The grout shall be applied without risk of floating the service pipe and without excessive external pressure on the service pipe that can result in unacceptable deflection or collapsing of the service pipe. The grout design and application method shall be submitted for review by the Engineer at least 14 days prior to the commencement of the grouting. The annulus grouting shall only be completed after successful testing of steel pipe coatings and the hydrostatic pressure testing of the service pipe.

10.6.7 Tolerances

The position of any point of the finished sleeve shall be within 100 mm horizontally and 30 mm vertically of the designed position. Adjustment to line or level shall be gradual and the pipe manufacturer’s stated maximum permissible draw or angular deflection shall not be exceeded at any joint. Misalignment between pipe units shall not exceed 10 mm.

The Contractor shall check line and level at least once during the installation of each pipe length, and should it be necessary, he shall take such corrective action as is required to bring the pipe within tolerance. A copy of the final levels and line and a statement of any corrective measures taken shall be available for inspection on the Site, and a copy shall be given to the Engineer as soon as the jacking has been completed.

The Contractor shall ensure a smooth, level and even surface on the inside of the jacking pipe to avoid problems during the installation of the service pipe, for example damage of steel pipe coating by pipe supports/straps/wheels/skids.

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SECTION 12

BLASTING

TCTA MODULAR STANDARDS
SECTION 12
BLASTING

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SECTION 12
BLASTING

12.1 SCOPE

This Section deals with the planning, design and execution requirements for blasting, and blasting methods to be used for bulk surface and trench excavation and excavation underground associated with pipe jacking operations.

This Section is a performance specification where the Contractor is responsible for the design of the blasting techniques required to excavate hard rock material and shall be read together with the approved Health and Safety Plan and the other relevant sections of the Specifications.

12.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

12.2.1 Definitions

In this Section the following words shall have the meaning given:

a) **"Blasting"** means the careful design and blasting, executed under the specific supervision of an approved blasting specialist, the Explosives Manager, to manage the general risks of blasting operations including the risk of damaging sensitive infrastructure near the blasting operations. (The Explosives Manager appointed in terms of Explosives Regulation 12(1) of the Occupational Health and Safety Act)

b) **"Controlled blasting"** comprises the use of a drilling and charging pattern that has the purpose of limiting overbreak and damage to the rock and comprises closer spacing of the perimeter holes plus reduced *decoupled* charges in these holes. It also comprises the use of delays in detonating the various rows of holes in the drilled pattern to limit vibration velocities. The four principal techniques of controlled blasting are smooth blasting, pre-splitting, line drilling and trim blasting. Normally, only smooth blasting is used underground and the other techniques are used in surface excavations.

c) **"Covered blasting"** means blasting where the deposition of flyrock on adjacent undisturbed areas shall be controlled by either placing blast mats or through placing a suitable layer of soil cover over the area to be blasted. The soil used for covered blasting shall not be topsoil or fertile soil as defined in Section 7 – Clearing Site.

d) **"Decoupling"** means that the diameter of the charge is smaller than the diameter of the hole so that an annular air space is provided around the charge. This air space absorbs some of the initial explosive energy and reduces the magnitude of the initial high-pressure impact that is responsible for the crushing of the rock immediately surrounding the hole.

e) **"Pre-splitting"** comprises drilling a line of closely spaced parallel holes of appropriate diameter, spaced not more than ten times the hole diameter or 600 mm, whichever is the smaller, charging the holes with an appropriate amount and type of explosive

(decoupled if necessary) to shear the rock, to form a surface along the line of drill holes. The pre-splitting holes will be initiated first prior to the main production blast.

f) **"Post-splitting"** comprises the drilling of a number of closely spaced parallel holes along the required excavation surface, with a suitable burden/spacing ratio, loading all the holes lightly with a uniform continuous charge of small diameter explosive and detonating all these charges simultaneously after the detonation of the main production blast, to form a surface along the line of drill holes.

g) **"Line drilling"** comprises drilling a line of holes of appropriate diameter spaced not more than twice the hole diameter to form a surface of weakness along which the rock will break. Blasting is not permitted in the line drilled holes, and the first line of production holes next to the line drilled holes shall be lightly charged to avoid damage to the line drilled break surface.

h) "**Smooth blasting**" comprises the drilling of a number of closely spaced parallel holes along the required final excavation surface, with a suitable burden/spacing ratio, loading all the holes lightly with a decoupled, uniform continuous charge of small diameter explosive, and detonating all these charges simultaneously, after the detonation of the main production blast.

i) **"Trim blasting"** comprises the separate removal of a protective zone of rock which has been purposely left within the specified limits of excavation for flat areas and shallow slopes. Drilling for trim blasting shall consist of a regular pattern of holes at appropriate spacings and angles and to accurate depths. The holes shall be lightly charged and detonated in relays to lift the rock progressively to form the final excavated surface without damaging the surrounding rock.

f) **"Overbreak"** means any excavation which extends beyond the excavation profile shown on the drawings, irrespective of the reason for such excavation. Overbreak shall be minimised by using an approved controlled blasting technique.

j) **"Public structures"** means any structure or building not associated with the project, i.e. houses, kraals, culverts, roads, water troughs, etc.

12.2.2 Abbreviations

dB: Decibel
NGL: Natural Ground Level
PDF: Portable Document Format
PPD: Peak Particle Displacement
PPV: Peak Particle Velocity
SANS: South African National Standard
USBM: United States Bureau of Mines

12.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions

thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

12.3 REGULATIONS

The storage of explosives, use of explosives, personnel, transport of explosives, and other matters related to explosives shall be governed by the relevant sections of the Explosives Act (Act 15 of 2003), Mineral and Petroleum Resources Development Act (Act 28 of 2002), Occupational Health and Safety Act (Act 85 of 1993), Construction Regulation 2014, Explosive Regulation and NEMA, together with their associated regulations, or such subsequent acts and regulations as may be promulgated.

The Contractor shall be solely responsible for proper storage, transport, importation, security arrangements both during transport to the Contractor's storage magazine(s) on Site as well as during blasting activities, and the correct possession and use of explosives.

The Contractor shall keep records in respect of receipt, storage and use of explosives.

The Contractor shall display in his Site office, and all his explosives magazines, a copy of any applicable statutory regulations, and the applicable section of the approved Health and Safety Plan.

A copy of all statutory appointments, certificates issued to workmen to permit them to undertake blasting, and to the Contractor to cover the purchasing, storage, transport and use of explosives shall be handed to the Engineer before any blasting work is undertaken.

12.4 SAFETY PRECAUTIONS

The Contractor shall store, transport, possess and use explosives in accordance the relevant sections of the Acts and regulations referred to in Clause 12.3.

Furthermore, the Contractor shall take particular precautions with respect to lightning, such as the use of non-electric detonators or electric detonators specially manufactured for use in such circumstances coupled with the use of lightning warning equipment or other appropriate measures.

The power circuit used for electric firing of explosives within underground works shall be hung on supports other than those used for electric power or communication lines and on the opposite side of the tunnel. Control of this circuit shall be by means of a locking switch with one key.
All electrical equipment, cabling, pipework, ducting, rails and the like used underground shall be grounded to an approved installation extending throughout the underground workings and connected to ground outside the entrance to the Works.

The Contractor shall install and operate a siren of sufficient volume to be easily heard above the general site noise from all points within a radius of 1.0 km of surface blasts. Hand operated sirens will only be accepted in areas of restricted access such as with underground works where access is fully controlled.

Blasting operations should be controlled to ensure sound pressure levels are kept below the generally accepted 'no damage' level of 140 decibels.

The Contractor shall employ industry standard methods to control the impact of blasting and limit the risk of damage to buildings and structures by reducing blast vibrations induced in the rock mass, eliminating fly rock and limiting air-blast and noise to acceptable levels. This should include pre-blast inspections of infrastructure.

12.5 GENERAL REQUIREMENTS

Controlled blasting shall be used for all excavations, inclusive of any stage-excavations such as top headings, central top headings, side drifts, benches, etc., in both surface and underground works.

Over and above the statutory appointment of the Explosives Manager in terms of Explosives Regulation 12(1) of the Occupational Health and Safety Act and the statutory appointment of the Blasting Supervisors in terms of the Explosives Regulation 12(3) of the Occupational Health and Safety Act, the Contractor shall employ a blasting specialist for the design of controlled blasting patterns for excavation in rock conditions in the various sections of the Works.

This blasting specialist shall be retained by the Contractor for the duration of the excavation of the Works and shall submit new designs to suit encountered rock conditions as and when required by the Blasting Supervisor. The name and CV of the Contractor's blasting specialist shall be submitted for approval to the Explosives Manager, prior to the blasting activities.

12.5.1 Programme and Method Statement

In the event of a situation arising in which the Explosives Manager or any Blasting Supervisor demonstrates consistent non-compliance with the requirements of this Section, incompetence and/or false representation, they shall, on the instruction of the Engineer in terms of Sub-clause 6.9 of the Conditions of Contract be summarily removed from site and be replaced by a competent person approved by the Engineer at no additional cost. Any delays caused as a result of this shall be for the Contractor's account.

Prior to commencing with blasting activities, the Contractor shall submit a Method Statement which should comply with the Explosives Regulations and all relevant SANS standards and health and safety standards for mitigating blasting. The Contractor shall submit to the Engineer full details of his proposed methods and sequence of excavation and programme for the use of explosives. The work shall be programmed so as to minimise blasting adjacent to already constructed sections of the Works.

The work shall be programmed so as to minimise blasting effects adjacent to previously constructed sections of the Works.

12.5.2 Blasting

All blasting work shall be carried out using carefully managed blasting techniques to minimise damage to the final excavation profile.

Use shall be made of suitable special explosives and/or blasting techniques which will minimise blasting-induced fractures, or disturbance, on the rock faces outside the excavation line so preserving the rock in the soundest possible condition and most importantly to minimize damage to nearby infrastructure.

The Contractor shall incorporate a series of blasting trials in his initial blasting operations to substantiate his proposed methods of blasting and methods of monitoring impact. As a minimum, four (4) trial blasts shall be conducted by the Contractor at the start of the Contract and, if required by the Engineer, continued until consistent seismographic results are obtained. Monitoring for these trials shall be both taken on existing pipe (to be exposed) or other structure and in the ground above it – both at the same distance from the blast. Details of all proposed blasting trials and procedures shall be submitted to the Engineer for review..

In underground work at least one of the trial blasts shall incorporate the full extent of the face to be excavated and maximum round length. In surface work the maximum depth and length of each trial section shall be 5 m and 10 m respectively. The site for the trials shall be agreed with the Engineer.

Once the results of the trials are approved, such results shall form the basis for deciding whether future controlled blasting is achieving the required standard.

Where blasting is necessary, the Contractor shall, in particular, note the requirement that he must limit to the maximum extent practicable the occurrence of fly rock, which may include, inter alia, the use of blasting mats, covering the rock prior to blasting with sufficient loose material to prevent the blasted material being thrown excessive distances from the blasting zone, timber boarding or other means to protect the Works and persons, animals and property in the vicinity of the Site. The Contractor shall accept responsibility for all injury or damage occasioned by any blasting operations and shall make good such damage without any additional payment.

Blasting methods shall be developed such that the weight of charge to be detonated at any precise moment is minimal and to include the use of time-delay detonators in order to reduce the extent of the overall impact of detonation.

The Contractor shall, in particular, note the requirement that he must limit to the maximum extent practicable the spillage of material from surface excavations, whether by blasting or other means, down adjacent hillsides. To this end the Contractor shall take all necessary precautions including, if

necessary, covered blasting, i.e. covering the rock prior to blasting with linked, anchored mats or sufficient loose material to prevent the blasted material being thrown down the adjacent hillside. If, during the course of excavation on a hillside, the Engineer is of the opinion that insufficient precautions are being taken to minimise the spillage of material, he may instruct the Contractor to adopt further measures to reduce the spillage. No separate payment will be made for any such measures required.

Each separate blast shall be designed in accordance with modern blasting practice to break out the rock with the minimum explosive force. Full details of each blast shall be submitted to the Engineer prior to the commencement of drilling for that blast. The details shall include the location, depth and area of blast holes, the type, strength, amount, column load and distribution of explosives to be used per hole, per delay and per blast, the sequence and pattern of delays, the maximum expected amplitude of vibration on adjacent structures taking cognisance of the requirements in Clause 12.10, and the description and purpose of any special methods to be adopted by the Contractor.

Submission to the Engineer of any blasting proposals shall not relieve the Contractor of his responsibilities under the Contract and the law.

Should the Contractor excavate to dimensions in excess of those specified, whether to remove damaged material or for reasons of safety or for his own convenience, he shall at his own expense, fill in the excess excavation with concrete of approved quality or with other material approved by the Engineer, or carry out additional trimming to the satisfaction of the Engineer.

12.5.3 Record of Excavations

Where blasting has taken place, the Contractor shall provide the Engineer each day with a copy of the record for the previous day's excavations. Where applicable the following data shall be recorded for each working area together with such other data as the Engineer may request:

a) Location of the excavation and position within the excavation;
b) Drilling pattern;
c) Type and amount of explosive used, including blasting pattern and delays used;
d) Details of rock conditions and rock support installed;
e) Number and classification of labour and Equipment;
f) Unusual occurrences, rockfalls, unstable or soft ground and inflows of water;
g) Blasting results and measured vs. predicted vibration levels;
h) Progress, delays and reasons for delays; and
i) Name and certification of the Explosives Manager and Blasting Supervisors.

12.6 QUALITY OF EXCAVATED SURFACE AND BLASTING TRIALS

The surface, after blasting, shall exhibit a regular fracture plane between barrels without back break and with half barrels visible over the major portion of the surface. The surface shall be scaled down of all loose and hollow sounding rock to leave a solid, intact surface. Light charges shall be used for

enlarging or correcting the excavated profile and also for excavating trenches. For example “Fox holes” are required approximately at 19 m centres along the new pipeline to provide access for welding and coating repairs.

For trench blasting, the width of the trench shall not exceed the limits required by the pipe design. In the case of significant overbreak resulting from highly weathered surface rock, agreement must be reached with the designer in terms of acceptable solutions. The solution shall be subject to the Engineer’s review. Particular care must be taken not to disturb any existing pipeline or related structures.

If, in the opinion of the Engineer, the methods of blasting are at any time causing excessive or undesirable disturbance of the rock mass surrounding the excavated space, he may order the Contractor to change his methods of blasting and/or carry out further blasting trials until the desired results are achieved. No additional payment will be made for any change or further trials ordered by the Engineer or any delays resulting there from.

12.7 MONITORING OF BLASTS

The Contractor shall supply and operate at least one approved blasting seismograph, which shall be used where necessary to monitor blasting work. The personnel responsible for the operation of the seismograph(s) shall satisfy the Engineer that they are experienced and competent in the setting up of all of the equipment in accordance with the standards required and in the downloading of the data files for printing and analysis immediately after blasting. For the trial blast (refer Clause 12.5.2) and during supplementary and controlled blasting, the Contractor shall locate a sensor above the buried pipe at least 0.5 m below natural ground level (NGL), firmly coupled to the ground. This shall be achieved by casting a cement block of 0.3 m diameter and depth with a threaded bolt projecting from the top to take the seismic sensor. The concrete shall be located in a hole and tamped down with soil and buried. All the readings during trial and normal blasting shall be accumulated and plotted in order to build up a knowledge base for propagation, if any.

The setting up and production of useful/informative records of the blasts will be reviewed and agreed between the Engineer and Contractor. These records shall accompany the daily records as described in terms of Clause 12.5. The RAW data files and .pdf printouts shall show the time and location of each blast, the type and amount of explosive used, rock type, together with any other relevant data. Copies of these records shall accompany the required daily records. The Contractor shall have access to a second instrument either for:

- occasional measurement on an existing pipeline;
- where surface structures need to be monitored; and
- as back up to the first.

The software necessary for viewing and analysing the files, including derivation of displacement and frequency components, shall be made available to the Engineer.

All blasting near structures and boreholes shall be monitored and recorded. The levels of vibration shall not exceed that specified by the blasting design specialist and in absence of that shall not exceed that indicated in Clause 12.10.

12.8 NOTIFICATION OF BLASTS

The Contractor shall notify the Engineer of his intention to blast at least 24 hours before that operation is carried out. The notification shall show the location of and the intended time of each blast and the name of the Blasting Supervisor and shift foreman responsible.

The Contractor shall distribute written notification to the Engineer, as well as suitable signage to adjacent communities and the public in the vicinity of the blast, prior to undertaking surface blasting in accordance with the relevant legislation. Any delay or postponement of any blast shall immediately be notified to the Engineer and the adjacent communities and the public in the vicinity of the blast. The firing of explosives above ground and in underground works shall be restricted to hours of daylight, daily with the exception of Sundays when no blasting shall be permitted.

The Contractor shall prepare a method statement for review by the Engineer on notification of affected parties, adjacent communities and the public in the vicinity of the blast.

12.9 BLASTING NEAR PIPELINES AND OTHER INFRASTRUCTURE

The unrestricted use of explosives will generally not be permitted in any part of the Works.

The Contractor shall be responsible for avoiding damage to adjacent infrastructures from flyrock by erecting barricades and/or the use of covered blasting or blast mats. Should damage be caused by any his operations this shall be made good without any additional payment.

The amount of energy released shall not result in a ground vibration with a peak particle velocity in excess of those recommended by USBM (see Table 12/1 below). In absence of directions provided by the blasting design specialist, the dominant blasting frequency for PPV's in excess of 25 mm/s should be in excess of 15 Hz.

TABLE 12/1
MAXIMUM PEAK PARTICLE VELOCITIES (VIBRATION)

Maximum Peak Particle Velocity (mm/s)	Effect on People and Buildings
0,5	Threshold of human perception unlikely to cause damage of any type
5	Limit for blasting adjacent to historical monuments
25	Limit for blasting near private dwellings in order to reduce disturbance to residents to a minimum

Maximum Peak Particle Velocity (mm/s)	Effect on People and Buildings
50	Limit for blasting adjacent to residential structures on good foundations
84	Limit for property owned by concern doing the blasting (i.e. minor plaster cracks acceptable)
120	Recommended maximum level for blasting adjacent to sturdy reinforced concrete structures

Where circumstances dictate, such as when blasting near to partially cured concrete, the peak particle velocity shall not exceed that specified in Table 12/2. These limits are to be applied in conjunction with those applied to any adjacent structures.

TABLE 12/2
SAFE GROUND VIBRATION LEVELS FOR FRESHLY POURED CONCRETE

Aged of Concrete (Days)	Maximum Peak Particle Velocity (mm/s)
< 3 Days	5
3 - 7 Days	51
8 - 10 days	102
10+ Days	203

Air Blast should be controlled by proper stemming control and cover blasting on shallower holes. The Air Blast Limits should not exceed 134 dB which is the current recommended South African limit as indicated in Table 12/3 below.

TABLE 12/3
DAMAGE LIMITS FOR AIR BLAST

Air Blast Level	Descriptions
125 dB	Complaints Start
>130 dB	Resonant response of large surfaces (roofs, ceilings)
134 dB	Recommended South African Limit
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

Blasting shall not be carried out within 5 m of the Permanent Works or other permanent infrastructure. Also refer to blasting in the proximity of Transnet and Eskom infrastructures and cables in Section 33.

The Contractor shall undertake a crack survey and prepare a photographic record of each structure, especially houses, buildings, ruins, farm dams, water troughs etc., of the local communities within 250 m of any Works, whether on the surface or underground, prior to any blasting taking place, to be verified by the owner in writing. A copy of this approved record shall be provided to the Engineer prior to any blasting taking place. In densely populated areas, a representative sample of dwellings agreed to by the Engineer shall be surveyed.

The Contractor shall also obtain from the owners, records of the yields/capacity of all boreholes and farm dams located within 50 m of any blast. A copy of the record, approved by the owner, shall be provided to the Engineer prior to any blasting taking place. Should a record not be available, the Contractor shall arrange for the necessary yield tests to be performed.

12.10 CONTROLLED BLASTING METHODS

12.10.1 General

Controlled blasting methods shall comprise drilling, pre-splitting, post-splitting or trim blasting.

Both cartridge and bulk explosives may be used where appropriate.

In controlled blasting the type, size, decoupling and charge concentration of perimeter and bulk charges shall be within established parameters unless otherwise proven acceptable by site trials.

All charges shall be accurately made up and inserted into the holes at the correct spacing, and all holes shall be correctly stemmed and connected in the correct sequence, with detonators being correctly delayed.

If, at any time, the methods of drilling and blasting do not produce the desired results of a uniform profile and shear face without overbreak, all within the tolerances specified, the Contractor shall be required to undertake further tests as specified in Clause 12.5.2 until a technique is arrived at that will produce the optimised results commensurate with the rock conditions.

Controlled blasting shall be used on the perimeter of all excavations in rock for the Permanent Works.

12.10.2 Drilling

In all controlled blasting, drilling accuracy of perimeter holes is of prime importance and the Contractor shall take particular care and make use of sight lines and guide rails in surface work to control the alignment and depth of blast holes. In underground works, use shall be made of drilling equipment with parallel arm controls. Holes which are likely to protrude more than 100 mm beyond the excavation profile (including any tolerances specified) shall not be charged up but shall be re-drilled.

In both surface and underground works the blast pattern shall be accurately set out and holes shall be collared within 50 mm of the required position. Holes which are over-drilled shall be fully stemmed to the required depth before charging up takes place.

In surface work, the depth of perimeter holes for any individual blast/round shall not exceed 10 m unless the Contractor can demonstrate to the Engineer that he can stay within the required tolerances, produce a uniform surface, and provide suitable access for all the subsequent necessary scaling, inspection, mapping and installation of the required rock reinforcement and support. In this event the length of holes may be increased to a maximum of 15 m. All perimeter holes for surface blasting shall be drilled to a depth of 10 hole diameters below the bottom of any production holes adjacent to the perimeter plane.

12.10.3 Pre-splitting

Critical to split formation is the instantaneous initiation of pre-split holes using either detonating cord, or electronic detonators. No down-hole pyrotechnic delay detonators are acceptable, but the split may be broken into runs of not less than 8 holes separated by a short delay where vibration is an issue.

Either all the holes in a pre-split line shall be drilled, charged and detonated simultaneously prior to drilling the production holes for the excavation adjacent to the presplit line, or pre-splitting shall be accomplished by delaying detonation in the production holes to allow the presplit holes to fire first. The first line of production holes next to the pre-split face shall be lightly charged to ensure that the presplit face is not damaged when the charges in the production holes are detonated.

The bottom charge of a pre-split hole shall not be larger than the line charges. The top charge of the pre-splitting hole shall be placed far enough below the collar to avoid over-breaking the final profile. In general, to prevent cratering and excessive movement, pre-split holes shall not be stemmed, but, where there is need to contain noise, the pre-split line shall be covered with adequate layer of soft soil or soil like material free of potential projectiles, placed on top of the tied-in blast and in sufficient depth to prevent flyrock.

12.10.4 Trim Blasting

Drilling for trim blasting shall consist of a regular pattern of holes at appropriate spacings and angles and to accurate depths. The holes shall be lightly charged and detonated in relays to lift the rock progressively to form the final excavated surface without shattering the surrounding rock.

12.11 CHECKING AND CORRECTING THE EXCAVATED PROFILE

The excavated profile shall be checked for line, level and underbreak. No projections of rock shall protrude within the designed excavation line, except as allowed within the specified tolerances.

The Contractor shall submit his proposals for removing any underbreak to the Engineer prior to carrying out any such work. Any work executed or delays, which are due to the Contractor having to re-excavate underbreak and then re-install support shall be carried out without additional payment, and no extension of time will be allowed for this work.

12.12 DISPOSAL OF EXPLOSIVES AND ASSOCIATED MATERIALS

Should the Contractor be granted permission by the relevant statutory authority to retain outdated explosives in a site magazine or storage place he shall immediately inform the Engineer and if requested to do so, furnish the Engineer with a copy of such authorisation. When any explosives are to be destroyed, the Engineer shall be informed at least 24 hours before the destruction is due to take place.

Under no circumstances may explosives be destroyed in any part of the underground works. Explosive wastes may only be destroyed legally and in all cases care shall be taken to avoid fire risks. This would include burning of waste in a contained area cleared of vegetation and where appropriate fire fighting equipment is in attendance. Cognisance shall be taken of the wind directions and the burning operation shall be appropriately supervised until the fires are fully extinguished.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 13

ROCK SUPPORT

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ROCK SUPPORT

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SECTION 13
ROCK SUPPORT

13.1 SCOPE

This Section deals with the supply, installation and testing of rock support for use in excavations, slope stabilisation and anchoring of the Works where required.

Rock support normally consists of one or more of the following elements:

a) Tensioned fully grouted or friction rock bolts;
b) Fully grouted dowels;
c) Anti-floatation anchors for reinforced concrete structures;
d) Mesh reinforcement; and
e) Sprayed concrete.

This Section shall be read in conjunction with Section 20: Concrete Works (Structural).

13.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

13.2.1 Definitions

a) **"Rock bolt"** means a high yield deformed bar of specified diameter and length (installed in rock) which is end anchored, fully column bonded with cement grout, equipped with a faceplate, hemispherical washer and nut and tensioned to a specified load.

b) **"Dowel"** means a high yield deformed bar of specified diameter and length (installed in rock) for which the protruding portion may be either straight or bent, and which is fully column bonded with cement grout. Dowels will not be tensioned.

c) **"Anti-floatation anchor"** means a high yield deformed bar similar to a "dowel" which is grouted with specified cementitious grout and which is used for anchoring reinforced concrete structures to rock.

d) **"Sprayed concrete (or shotcrete)"** means concrete projected pneumatically onto a receiving surface to produce a dense, homogeneous mass. Sprayed concrete normally incorporates admixtures and may also include additions of fibres or a combination of these.

e) **"Overspray"** means sprayed concrete placed outside of the intended receiving surface.

f) **"Rebound"** means sprayed concrete material that ricochets off the receiving surface and falls to accumulate on the ground or other surface.

g) **"Sloughing, or sagging"** means subsidence of sprayed concrete, due generally to excessive water in the mix or placing too great a thickness of sprayed concrete in a single pass.

13.2.2 Abbreviations

ASTM: American Society for Testing and Materials

BS: British Standard
CEM: Calcium-Enriched Mixture
CSF: Condensed Silica Fume
DCP: Double Corrosion Protection
DSI: DYWIDAG Systems International
EFNARC: European Federation for Specialist Construction Chemicals and Concrete
EN: European Norm
FA: Fly Ash also known as Pulverised Fuel Ash (PFA)
GEWI®: Registered International Patent Holder of the GEWI Threadbar System
GGBS: Ground Granulated Blast-Furnace Slag
GGCS: Ground Granulated Core Slag
IRSM: International Railway Strategic Management (Corten IRSM steel)
JSCE: Japan Society of Civil Engineers
MQC: Manufacturing Quality Control
OPC: Ordinary Portland Cement
RHPC: Rapid-Hardening Portland Cement
RPM: Revolutions Per Minute
SANS: South African National Standard
SANAS: South African National Accreditation System
UFC: Ultra Fine Cement

13.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014, Construction Regulation 28, stacking of rock materials and hazardous chemical substances Regulation when exposing employees to resins and cement products.

13.3 ROCK BOLTS AND DOWELS

13.3.1 General

Where required, galvanised rock bolts and rock bolt accessories or dowels shall be used. Galvanizing shall be in accordance with Section 37 – Painting and Corrosion Protection, to a mean coating thickness of 85 microns.

The Contractor shall be responsible for checking and maintaining the rock support in a sound condition. The correct seating of face plates and tightness of nuts shall be ensured.
The Contractor shall provide Method Statements for installation and testing of all temporary and permanent rock support elements to the Engineer for review prior to the start of rock support work.

Method Statements shall *inter alia* provide the following:

a) Details of the dowels and rock bolts to be used;
b) Details of any proprietary rock support systems proposed, with supporting test data;
c) Details of the method of corrosion protection;
d) Details of drilling methods and equipment;
e) Details of all equipment and accessories to be used for dowel and rock bolts installation;
f) Details of the proposed grouting procedures and admixtures, and if so requested, samples of the proposed grouting admixtures; and
g) Details of equipment and methods to be used for pull testing of dowels and rock bolts, with calibration certificates attached.

13.3.2 Materials

Temporary tensioned rock bolts and dowels shall consist of either:

a) Deformed steel bars (reinforcing Y-bars) with a minimum yield stress of not less than 450 MPa complying with SANS 920 and with a minimum threaded length of 150 mm at one end with a coarse cut thread which shall not reduce the overall specified bar diameter by more than 3 mm, and cut at an oblique angle at the other end to facilitate installation when using resin or cement grout cartridges; or
b) Deformed steel bars (GEWI bars or equivalent) with a minimum yield stress of not less than 540 MPa.

Permanent tensioned rock bolts and dowels shall consist of deformed steel bars (GEWI bars or equivalent) with a minimum yield stress of not less than 540 MPa and are to be of the DSI DCP type with double corrosion protection.

Face plates shall be of the 150 mm diameter (or alternatively, 150 mm x 150 mm square), 8 mm thick domed load (10 tonne) indicating type.

The face plates shall be fitted with a hemispherical washer to permit seating of the face plate at inclinations up to 30° from normal to the bolt.

Grout for rock bolts and dowels shall consist of either:

a) Resin grout which shall be a commercially produced epoxy product in capsule form with both fast and slow setting times as applicable especially formulated for use with rock bolts or dowels, and transported, stored and utilised in accordance with the manufacturer's recommendations; or

b) Cement grout which shall be a commercially prepared product in capsule form especially produced for use with rock bolts or dowels. The product shall not contain any material which could corrode the rock bolts or dowels.

Where Site conditions are appropriate, mechanically anchored rock bolts may be used. All such mechanically anchored bolts shall comply with the latest requirement of the Chamber of Mines for rock bolts. All mechanically anchored rock bolts which are installed but are not thereafter fully grouted, shall be checked and re-tensioned as required.

13.3.3 Manufacture of Rock Bolts

Rock bolts shall be manufactured from high yield deformed bar to the required lengths and diameters and with a characteristic strength of at least twice that of the specified working load. The bar length specified shall be the required length of bar to be bonded to the rock and due extra allowance in the cutting length shall be made for any other length including the threaded portion protruding from the rock and for the mechanical anchorage as required for installation. A minimum threaded length of 150 mm shall be allowed beyond the nut on installation to allow tensioning of the rock bolt. Face plates shall be 150 mm diameter (or alternatively, 150 mm x 150 mm square), domed, deformable plates of the load indicating type. The face plates shall deform at minimum 80% of the specified working load of the bolt, and its performance verified by means of Site trials prior to the commencement of any excavations. Installation and testing of rock bolts during such trials shall be carried out using the same equipment, including hydraulic tensioning device, as will be used in the Works.

The face plates shall be fitted with a hemispherical washer to permit seating of the face plate at inclinations up to 30° from normal to the bolt.

13.3.4 Manufacture of Dowels

Dowels shall be manufactured from high yield, deformed bar in the required lengths and diameters.

Dowels shall be either straight bars or shall have the protruding end bent to facilitate the specified anchor between the rock and the surrounding concrete or sprayed concrete.

Dowels for installation with resin or cement capsules shall be threaded at one end sufficiently for attachment of the installation equipment. The other end shall be chamfered to facilitate installation.

13.3.5 Testing of Rock Bolts and Dowels

Prior to the installation of rock bolts or dowels in the Works, the Contractor shall carry out a series of tests as agreed with the Engineer to prove the capacity of the system and the Contractor's capability to correctly install dowels and rock bolts and tension the rock bolts.

The tests shall demonstrate:

- The anchorage assembly required to provide the end anchorage with an applied load equal to the bar's characteristic strength and taking into account the over-length variation of holes. The anchorage assembly may consist of resin or grout cartridges or a mechanical anchorage;
- The number of cartridges to fill the annulus around the rock bolt over the length of the hole between the anchorage and collar of the hole;
- The strength of the cement or resin grout to fully anchor the bars up to the characteristic strength of the rock bolts;
- The capacity of the equipment to install the longest required fully grouted rock bolts;
- The equipment required for tensioning the bolts to the specified loads; and
- The capability of each crew to correctly install and tension the rock bolts.

The Contractor shall undertake the tests with the equipment to be used on the Works.

The Contractor shall provide a suitably calibrated hydraulic direct tensioning jack and/or load cell of capacities in excess of 1,5 times the maximum characteristic strength of the rock bolts to be used in the Works. Loads applied and bolt elongations shall be recorded during the tests.

13.3.6 Installation of Rock Bolts

Manufacturer's instructions for the use of proprietary components shall be followed wherever these exist. Rock bolts shall be installed as soon as possible after excavation.

Unless otherwise proven acceptable by Site trials, the rock bolts shall be installed in percussion drilled holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the rock bolt. Holes in excess of this diameter shall be abandoned and re-drilled. The holes shall not be more than 100 mm longer than the grouted length of the rock bolt unless otherwise proven acceptable by Site trials. Holes shall be drilled straight and to an accuracy of ± 5 degrees. Holes shall be cleaned by flushing with compressed air or clean water to remove debris immediately prior to installing the rock bolt. Where holes are cleaned by flush water, the amount of water employed shall be kept to an absolute minimum. Sufficient cementitious grout or cartridges of cement / resin grout shall be used to ensure the annulus around the rock bolt is completely filled over the full length of the hole.

Where utilised, end cartridges for the anchorage zone shall be of fast setting resin whilst the column shall be filled with slow setting resin or cement cartridges. Tensioning shall be carefully controlled to ensure that it takes place after setting of the end cartridges but prior to commencement of setting of the column grout.

Alternatively, the column of the rock bolt shall be filled to the collar of the hole using pumped cement grout, after tensioning of the rock bolt as specified.

The rock bolts shall be centrally located in the drilled holes and held in position by means of non-corrosive spacers which shall be firmly secured in position. Wooden spacers shall not be used.

The rock bolts shall be tensioned to 10 tonnes.

Tensioning of rock bolts shall be carried out by means of a device imparting a direct pull to the bolt. The device shall be fitted with a gauge to indicate the tension in the bolt and shall be calibrated at regular intervals.

Those parts of the bolts that are to be grouted or surrounded with mortar or epoxy resin shall be cleaned of grease, oil, loose rust or other matter that may impair the bond.

The Contractor shall comply with hazardous chemical substances Regulation when exposing employees to resins. All employees to be issued with correct PPE when working with hazardous chemicals.

13.3.7 Installation of Dowels

Manufacturers' instructions for the use of proprietary components shall be followed wherever these exist.

Percussion drilled holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the dowel shall be drilled and cleaned as required. Holes shall be drilled straight and to an accuracy of ± 5 degrees and shall not be more than 100 mm longer than the grouted length of the dowel unless otherwise proven acceptable by Site trials. Where holes are cleaned by flush water, the amount of water shall be kept to an absolute minimum.

The dowels shall be centrally located in the drilled holes and held in position by means of non-corrosive spacers which shall be firmly secured in position. Wooden spacers shall not be used.

The gauged amount of pumped cement grout or capsules of resin or cement grout shall then be inserted and the bar driven firmly into the hole (by spinning in the case of capsules). If pumped cement grout is used, the grout shall be inserted using a tremie pipe pushed down to the bottom of the hole and withdrawn slowly as the grout is placed. After installation the bar shall be vibrated for a short period to ensure the complete distribution of the grout around the full length of the bar. Additional grout shall be added to make up any shortfall. Where specified, grouting of the hole shall be carried out in stages to allow the flow of grout into cavities, each stage being topped up by the successive stage.

Those parts of the dowels due to be grouted or surrounded with grout shall be cleaned of grease, oil, loose rust or other matter that may impair the bond.

13.3.8 Routine Quality Control Testing

The Contractor shall carry out in-situ tests on dowels and rock bolts installed in the Works as agreed with the Engineer. Testing is to be generally in accordance with the procedures given in the ISRM Suggested Methods for Rock bolt Testing.

The Contractor shall check the effectiveness of both the dowel and rock bolt installation procedures by testing a minimum of 1 in 200 units installed to a test load of 70% of their specified characteristic strengths.

Dowels shall be tested after the grout has achieved its design strength. Rock bolts shall be tested after the rock bolt has been tensioned but prior to the free column of the bolt being filled with pumped cement grout. Tests on rock bolts selected for such routine quality control testing shall be carried out prior to full column cement grouting of the free length of the rock bolt.

Any dowel or rock bolts that fails at a tension of less than or equal to 70% of its specified characteristic strength shall be replaced. Also, in such event, for the last 200 dowel and/or rock bolts units installed, the end anchorage zone of such rock support will be considered unbonded from the rock and additional rock support shall be installed over the affected surface area of the excavation with the diameter, length and spacing of such additional support as directed by the designer. The Contractor shall install such additional support before advancing the excavation any further.

The Contractor shall furthermore investigate the cause of such failure and make such proposal for amendment of the installation procedure as may be necessary. Tests shall continue thereafter at a rate of 1 in 50 units installed until the Engineer is satisfied that the cause of the failure has been overcome. Should 1 in 50 dowel or rock bolt units thereafter tested still fail at tensions of less than 70% of its specified characteristic strength, then all further work in that portion of the Works shall be suspended and the Contractor shall install trial rock bolts and conduct pull-out tests on trial rock bolts installed outside that area of works as required.

The Contractor shall carry out regular calibration of hydraulic tensioning devices.

13.4 ANTI-FLOATATION ANCHORS FOR REINFORCED CONCRETE STRUCTURES

13.4.1 General

In addition to the requirements for rock bolts and dowels specified in Clause 13.4, the below shall apply specifically to Anti-floatation anchors for reinforced concrete structures.

13.4.2 Drilling of Holes for Anti-floatation Anchors

On completion of the drilling, each hole shall be thoroughly flushed with water to ensure good grout to rock bond.

The drill hole shall commence at the designated location within a tolerance of ± 150 mm. The alignment shall be within an angular tolerance of ± 2° and shall not vary by more than 3% of the length of the hole to that point.

Downward inclined holes shall be drilled 100 mm longer than the anchors to provide a sump for debris that cannot be washed out.

13.4.3 Water Testing of Holes for Anti-floatation Anchors

Prior to installation of any anchor, the hole shall be tested for water tightness by checking the total water loss along the full length of the hole. Where the water loss exceeds 5 litres/minute at a pressure of 100 kPa in excess of the local water table (which shall be measured) over a period of 10 minutes, the hole shall be cement grouted, re-drilled and retested until the water loss is less than this criterion.

13.4.4 Cement Grout for Anti-floatation Anchors

Material used for grouting shall comply with the following requirements:

- Cement shall comply with SANS 50197-1 and be of the strength class 32.5 or higher;
- Sand shall comply with the requirements of SANS 1083 for sand for concrete, except that the grading shall be such that 100% passes through a 1.18 mm;
- Admixtures shall not contain chlorides, nitrates, sulphides or sulphites and when aluminium powder is used, the total expansion of grout shall not exceed 10%; and
- Water for mixing grout shall comply with the requirements of EN 1008.

The Contractor shall carry out tests to determine whether the grout complies with the requirements for fluidity, bleeding and strength.

A suitable plasticizer shall be used in the grout. The grout shall be tested by placing a 100 mm high sample of grout in a covered cylinder of approximately 100 mm, fitted with a thermometer, to ensure that the temperature is kept at 20ºC ± 2ºC. The bleeding shall not exceed 2% after 3 h, or 4% max, when bleeding is complete, and the bleed water shall be re-absorbed fully after 24 h.

To determine the compressive strength of the grout a sample shall be taken in accordance with SANS 5861-2 and tested in accordance with SANS 5863. Cubes (of sides 100 mm) cured at temperature of 22ºC to 25ºC and at a relative humidity of at least 90% for the first 24 h, and kept in water at 22ºC to 25ºC, shall have a compressive strength that exceeds 20 MPa at 7 days.

The viscosity of grout for horizontal holes shall be 500 to 2 500 cP and for vertical holes 400 to 1500 cP, when measured using a standard flow cone in accordance with ASTM 939. The viscosity of the grout, 20 minutes after mixing, shall not exceed 2 500 cP and 1 500 cP for horizontal and vertical holes respectively.

When grout is mixed, first water shall be added to the mixer and then the cement. Only after the water and cement have been thoroughly mixed shall any admixture or sand be added. Mixing shall be continued until a uniform consistency is obtained but, in any event, for at least 2 min. The water cement ratio of the mix shall be as low as possible within the mass fraction range 0.35 to 0.5 and the mix shall have the required fluidity. Mixing shall not be done by hand.

13.4.5 Installation of Anti-floatation Anchors

The gauged amount of grout shall be introduced using a tremie pipe pushed down to the bottom of the hole and withdrawn slowly as the grout is placed. The anchor shall then be driven firmly into the hole and vibrated for a short period after insertion to ensure the complete distribution of the grout around the embedded length of the anchor. Excessive bleeding of the grout shall be avoided. Additional grout shall be added to make up any shortfall.

Immediately before being placed in the hole the anchor shall be thoroughly cleaned of mill scale, rust, mortar, oil, paint, dust, grease, soap or any other coating or foreign matter.

The anchors shall be centrally located in the drilled holes and held in position by means of non-corrosive spacers and which shall be firmly secured in position. Wooden spacers shall not be used.

Anchors shall be installed at least 5 days prior to the fixing of reinforcement, concreting or other work in the vicinity. Care shall be taken to not in any way disturb the anchors during this period.

13.5 WELDED MESH REINFORCEMENT

13.5.1 General

Welded mesh reinforcement shall comply with the relevant requirements of Section 20 - Concrete Works (Structural).

The mesh shall be securely fixed as described below, generally in hollows at the optimum distance from the rock face for the application process such as to minimise sprayed concrete rebound and prevent voids. The minimum cover between the mesh and the exposed face of the sprayed concrete shall be 25 mm. The mesh shall be set at a nominal distance of 20 mm from the rock face. Joints shall be lapped by 2 full squares.

Where welded mesh is used without initial sprayed concrete support, all loose material behind the welded mesh shall be completely removed before concrete is placed against the rock face. The welded mesh may be cut open to remove loose rock prior to lining. Continuity of the welded mesh shall be restored if required for safety but otherwise the welded mesh shall be trimmed neatly so that there are no loose portions which might interfere with the concreting operation.

13.5.2 Fixing Arrangements for Drill and Blast Drives

Mesh reinforcement shall be retained to the rock by one of the following methods:

a) Where mesh reinforcement consists of squares greater than 100 mm x 100 mm (i.e. mass 1.93 kg/m^2 for use in Shotcrete), mesh retaining spiders shall be fixed beneath the faceplate of the rock bolts such that the mesh reinforcement may be later secured with sufficient wire ties to the spider. Spiders shall consist of either eight (8) No. 6 mm diameter mild steel legs each 800 mm long or four (4) No, 8 mm diameter mild steel legs each 800mm long. In addition, mesh fixing pins shall be provided at intermediate points as required, but not exceeding 1 m centres both ways.
b) Where mesh reinforcement consists of squares 100 mm x 100 mm or smaller (i.e. mass 1.56 kg/m^2 for use without Shotcrete), the mesh may be fixed beneath the bolt faceplate and with intermediate fixing pins at a maximum spacing of 600 mm.

The mesh shall be fastened in such a way that if shotcrete is to be applied subsequently, the mesh will not sag or vibrate excessively and impair the effectiveness of the shotcrete.

Where mesh is required to be placed after an Initial layer of shotcrete has been applied to the excavated surface, the mesh shall be fixed to the excavated surface by means of pins, bolts, wire ties or loops or other suitable fixings fastened to rock bolts already in place. The mesh shall sit snugly against the initial shotcrete layer.

13.6 DOUBLE TWISTED WIRE MESH

Double twisted wire mesh rolls shall be used for the protection of slopes and cliffs where there may be danger of falling rocks.

All wire shall be hexagonal-woven Mesh type 80, zinc coated by hot-dip galvanising, as specified for 0.2 m – 0.3 m deep gabions in Section 21 – Gabions and Reno Mattress Structures.

13.7 SPRAYED CONCRETE (SHOTCRETE)

13.7.1 General

Shotcrete shall be applied to the rock surface where required as soon as possible after excavation. .

Shotcrete shall be applied to both clear and mesh reinforced faces and to the final thickness. Large radius irregularities will be permitted, but local roughness and re-entrant angles are to be covered and smoothed out by the application of additional sprayed concrete.

Shotcrete shall be applied by the wet mix process.

Where required, Shotcrete shall be applied in one or more layers to reach the specified total thickness.

The Shotcrete after completion is not to be touched up, trowelled, smoothed off or worked in any way, but left undisturbed.

The Contractor shall submit the following to the Engineer for review prior to first application of Shotcrete:

- Mix designs of all proposed sprayed concrete mixes, including test results demonstrating conformance with design requirements and compatibility of all mix components;
- Certificates of compliance with the relevant standards for the materials specified, with the source of such materials indicated;
- Qualifications, experience and work functions of personnel assigned to sprayed concreting; and
- Details of all equipment to be used for batching, mixing, conveying, applying and curing.

13.7.2 Materials

13.7.2.1 Cement, Cement Extenders and Water

Cement, cement extenders, and water shall comply with the requirements of Section 20 – Concrete Works (Structures).

13.7.2.2 Aggregates

Aggregates shall comply with the requirements of Section 20 - Concrete Works (Structural), except as regards grading requirements which shall be as given in Table 13/1.

The nominal particle size shall be 10 mm and the grading shall lie within the envelope given in Table 13/1.

TABLE 13/1
AGGREGATE GRADING LIMITS

Sieve Size (mm) (ASTM)	Percentage Passing by Mass	
	Maximum	Minimum
9.50	100	100
4.75	100	70
2.36	100	45
1.18	75	30
0.60	50	18
0.30	30	10
0.15	15	5

Aggregates with gradings outside these limits will not be accepted unless the Contractor has demonstrated in full-scale trials that a satisfactory end product can be produced with such aggregates.

13.7.2.3 Admixtures

The percentage of chlorides in admixtures shall not exceed 0,1% by weight. Apart from this, admixtures shall not contain any substances corrosive to steel and shall not induce other detrimental effects such as cracking or spalling.

Accelerators shall not be caustic or corrosive to reinforcement, and shall be of a type with a history of satisfactory long term performance.

Only the minimum quantity of accelerator necessary shall be permitted in normal concrete spraying operations, with the quantity to be used to be determined in Site trials. The amount of accelerator to be used shall be within limits recommended by the manufacturer but shall not exceed 3% by mass of the total cementitious content unless the Contractor can satisfy the Engineer that the 5 year strength of the Shotcrete will not be detrimentally affected. Accelerators showing excessive variability with dosage will not be permitted.

Accelerators delivered to Site shall be tested at least once every two months for their reaction with the cement used with particular reference to the setting behavior, early strength and decrease of strength after 28 days. Storage times and working temperature ranges shall be in accordance with the manufacturer's recommendations and the manufacturer's safety instructions shall be observed.

Plasticisers and retarders complying with Section 20 (and, where relevant, appropriate international standards e.g. ASTM C1141M-15) may be used to reduce the quantity of the mixing water and to improve the pumpability of the concrete. Plasticisers and retarders shall be checked regularly for setting time, water reduction and the development of strength as compared with the base concrete. Compatibility of plasticisers and retarders with cements, latent hydraulic binders and accelerators shall be verified during Site trials.

Hydration control admixtures may be used to control hydration of the mix as appropriate to expedite construction. The effects and optimum dosages of hydration control admixtures shall be determined during the Site trials. Compatibility of hydration control admixtures with cements, latent hydraulic binders and accelerators shall be verified during Site trials. Such admixtures shall be used in accordance with the manufacturer's instructions.

13.7.2.4 Compressed Air

Compressed air used in the process shall be clean, dry and free of oil.

13.7.2.5 Fibre reinforcement

a) Steel fibres shall comply with ASTM 820 – Standard Specification for Steel fibre for Fibre Reinforced Concrete. A minimum fibre tensile strength of 1 000 MPa is required.

Steel fibres shall be Type 1 deformed of equivalent diameter 0.5 mm and aspect ratio of 40 to 80. The length of fibre should not exceed 70% of the internal diameter of the hoses or pipes to prevent blockage.

Fibres shall be stored in dry sealed containers until ready for use and shall be free from corrosion, oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spraying processes or which may reduce the bond between the fibres and the sprayed concrete.

b) Where specified, synthetic fibre reinforcement shall be used provided that it complies with the specified performance requirements for fibre reinforced sprayed concrete.

Fibres shall be stored in dry sealed containers until ready for use and shall be free from corrosion, oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spraying processes or which may reduce the bond between the fibres and the sprayed concrete.

c) Fibre suppliers must be able to satisfy the performance criteria of the Works Information by means of an appropriate and established energy absorption panel test, to be carried out during the Site trials, as described in ASTM 1550-19: Standard Test Method for Flexural Toughness of Fibre Reinforced Concrete (Using Centrally Loaded Round Panel) or as alternative, the European Specification for Sprayed Concrete, EFNARC (1996 and Final Version June 1999).

13.7.2.6 Pigment

Where required, pigment shall be added to the sprayed concrete. An inorganic pigment suitable for use in concrete/shotcrete shall be used. The pigment shall be dosed at 5% by mass of cement. The colour of the pigment shall be as agreed with the Engineer.

13.7.3 Design of Sprayed Concrete

Sprayed concrete mixes shall be capable of placement without excessive rebound or segregation, and of meeting the specified strength requirements with the lowest practicable water/cement ratio.

Sprayed concrete shall meet the requirements specified in Table 13/2.

The mixes for sprayed concrete shall lie within the following proportions:

a)	Cementitious content	380	-	480 kg/m^3
b)	Aggregate/cement ratio	3.00	-	5.00
c)	Water/cement ratio	0.35	-	0.45
d)	Silica fume where required	30	-	50 kg/m^3
e)	Steel Fibre where required	30	-	80 kg/m^3 (i.e. 0,5 to 2,0 % by volume)
f)	Synthetic Fibre where required	4,5	-	18 kg/m^3

Water/cement ratio is defined as the mass of the free water in the mix divided by the total mass of cementitious material in the mix.

Minimum admixture should be used to obtain the specified early strength appropriate to the conditions.

TABLE 13/2
SPRAYED CONCRETE PERFORMANCE REQUIREMENTS

Sprayed Concrete Class		A	B	C	D
Description	**Test Method**	**Plain**	**Plain + Accelerator**	**Fibre Reinforced**	**Fibre Reinforced + Accelerator**
Compressive Strength:					
- at 8 hours (MPa)	SANS 5865	n/a	5	n/a	5
- at 24 hours (MPa)	SANS 5865	n/a	8	n/a	8
- at 28 days (MPa)	SANS 5865	35	40	40	40
First Crack and Ultimate Flexural Strength:					
- at 28 days (MPa)	SANS 5864	3,5	4	4	4
Residual Flexural Strength:					
- at 28 days (MPa)	SANS 5864	n/a	n/a	3,2	3,2
At 28 days:					
- I_{20} Toughness Index	SANS 5864	n/a	n/a	16	16
- I_{30} Toughness Index	SANS 5864	n/a	n/a	22	22
- I_{50} Toughness Index	SANS 5864	n/a	n/a	30	30
Boiled Absorption: - at 7 days (%)	ASTM C642-13	8	9	8	9
Volume of Permeable Voids: - at 7 days (%)	ASTM C642-13	17	19	17	19
Setting Time:					
- Initial Set (minutes)	ASTM C403/ C403M-99	n/a	3	n/a	3
- Final Set (minutes)	ASTM C403/ C403M-99	n/a	9	n/a	9
Toughness Classification (also see Note (iii) below)	EFNARC 1999	n/a	n/a	Class b	Class b

Notes: i) The above values are all 'minimum' acceptable limits except for boiled absorption and volume of permeable voids, which are 'maximum' acceptable limits;
ii) n/a indicates 'not applicable'; and
iii) Or equivalent toughness class in terms of the ASTM 1550-19 classification.

13.7.4 Acceptance Testing

Trial mixes shall be prepared employing the equipment and labour to be used on the Works and sprayed in test panels to the required thickness. Constituent materials shall be fully representative of those to be used in the Works.

As minimum requirement, test panels of at least 1000 mm x 1000 mm in size and 200 mm thick and with sides splayed outwards at 45° to prevent the entrapment of rebound, shall be sprayed in the presence of the designer for each mix design. The test panel moulds used shall be constructed of steel or other rigid, non-water absorbing materials.

The sprayed concrete in the panels shall adhere well to the back form, be properly compacted and exhibit no sagging.

Test panels shall not be moved for 18 hours after spraying and shall be stored without disturbance at a temperature of +20°C (± 5°) and covered by polythene sheet until the time of coring.

Cores for 8 hours, 24 hours and 28 day compressive strength tests shall be obtained from each panel with cores for 24 hours and 28 day strength tests to be stored in water, in accordance with SANS 5865 (1994). Each cored cylinder shall be marked with an appropriate reference mark and the date and time of spraying.

No two cores to be tested at any given age shall come from the same panel. Cores to be tested at different ages (i.e. 8 hours, 24 hours and/or 28 days) may come from the same panel. For each age of testing, at least one spare specimen shall be provided. In accordance with SANS 5865 (1994), the testing requirements shall be:

- Compressive strength in spray direction after 8 hours, 24 hours and 28 days on 3 cores each. The prepared test cores shall be 100 mm diameter and 100 mm long; and
- Compressive strength perpendicular to spray direction after 8 hours, 24 hours and 28 days on 3 cores each. The prepared test cores to be taken from the different panels, shall be 100 mm diameter and 100 mm long.

The sprayed concrete density of all test cores shall be determined prior to testing, in accordance with SANS 6251 (1994).

Sufficient panels shall be sprayed to also allow testing to prove the acceptability of the sprayed concrete to meet the requirements with regard to (refer Table 13/2):

- First crack and ultimate flexural strengths (minimum of 3 beams to be tested for every trial mix design, cut from separate test panels) (SANS 5864);
- Toughness indices (SANS 5864);

- Boiled absorption (ASTM C642-13);
- Volume of permeable voids (ASTM C642-13);
- Setting time (ASTM C403/C403M-99); and
- Energy absorption of fibre reinforced sprayed concrete panels (ASTM 1550-19 or EFNARC (1996 and Final Version June 1999)).

The Contractor shall carry out such other tests and trials during the period of Site trials as may be necessary to confirm that proposed mixes and methods meet the minimum performance requirements.

Based on the above requirements, Table 13/3 summarises the minimum number of core specimens required per spraying position per trial mix for testing as part of this programme.

TABLE 13/3
NUMBER OF SPECIMENS REQUIRED/SPRAYING POSITION/TRIAL MIX

Description	Test Method	Min. No. of Specimens to be Tested (Min. No. of Spare Specimens to be Available)		
		8 hours#	24 hours#	28 days
Compressive strength of cores in direction of spraying	SANS 5865	3 (1)	3 (1)	3 (1)
Compressive strength of core perpendicular to direction of spraying	SANS 5865	3 (1)	3 (1)	3 (1)

# denotes 'where applicable', refer Sprayed Concrete Classes, Table 13/2

Similarly, Table 13/4 summarises the minimum number of other specimens required per trial mix for testing as part of this programme.

TABLE 13/4
NUMBER OF OTHER SPECIMENS REQUIRED/TRIAL MIX

Description	Test Method	Minimum Number of Specimens to be Tested
Flexural strengths and toughness indices from testing fibre reinforced sprayed concrete beams	SANS 5864	3 (tested at age 28 days) (+ 1 spare)
Boiled absorption, volume of permeable voids	ASTM C642-13	5 (tested at age 7 days)
Setting times	ASTM C403/C403M-99	5

The compressive strength of cylindrical cores cored from test panels, cored either in or at right angles to the direction of spraying, shall be acceptable if the average result for 3 cores tested at 8 hours, 24 hours and 28 days is not less than the respective 8 hours, 24 hours and 28 day specified

strengths as listed in Table 13/2, and with no individual core having less than 70% of the specified strength.

The Site trials shall be repeated if the source or quality of any of the materials or the mix proportions is to be changed during the course of the Works.

Should any mix fail to produce satisfactory results in terms of the above acceptance testing, the Contractor shall repeat the spraying of panels and test either the same mix, equipment and labour or make such adjustments as he considers necessary to achieve the required performance.

The Contractor shall provide all material, labour and equipment required for preparation of test panels and the extraction of cores therefrom. The Contractor shall provide an on-Site facility for sample preparation and compressive strength testing of cores at 8 hours. However, the Contractor may propose alternative methods for assessing the strength of sprayed concrete at 8 hours (e.g. the Hilti method (1992) and/or a pull-out test as described in JSCE-G561-1999). Acceptance by the designer will be subject to satisfactory evidence of an acceptable correlation between such tests and the tests prescribed in the Works Information. The Contractor shall carry out all other testing at an appropriately accredited testing laboratory.

13.7.5 Equipment

The sprayed concrete gun and ancillary equipment shall be of adequate capacity for the volumes to be applied. At least one equipment shall have a minimum output of 5 m^3/hr. The equipment shall be capable of handling and applying 13 mm maximum size of aggregate. A stand-by gun and ancillary equipment shall be available at all times. Air for the equipment is to be provided to the equipment at not less than the operating pressure specified by the manufacturer.

Dosing of additives by hand will not be permitted. Equipment for dosing additives shall be adjustable for various quantities and provide a uniform rate of discharge evenly mixed with the other ingredients of the mix. The equipment shall be capable of delivering admixture to ensure the required dosage ratio to an accuracy of ±5%.

The working area shall be well illuminated to a minimum lighting intensity of 50 lux. Cap lamps attached to safety helmets will not be accepted as sufficient. Dust pollution shall be minimised by means of pre-damping of materials, additional ventilation, water sprays, and maintaining equipment in good order.

13.7.6 Batching

Materials shall be batched by mass of dry materials and cement shall not be added more than 1 hour before the anticipated time of placing the sprayed concrete unless a retarder has been used. Mixed ingredients shall be placed before the initial set of the cement has taken place. Aged material shall be discarded.

The batching accuracy shall be within ± 3% for all constituents. Admixtures may be measured by volume, to an accuracy of ± 5%.

Batching and mixing shall be carried out by equipment capable of properly mixing materials in sufficient quantity to maintain the continuous application of sprayed concrete.

Feed systems for all materials are to be interconnected such that the correct proportions are maintained irrespective of feed rate and if one feed stops, the whole equipment stops.

Batching and mixing equipment shall be cleaned at least once per shift to prevent accumulations of aged material.

The addition of fibres, if required, shall be at a stage in the mixing suitable for the sprayed concreting equipment. The procedure for the addition of fibres shall be determined during Site trials. Fibres shall be added and mixed in a manner to avoid clumping and bending of the fibres. Any fibre clumps in the mix shall be diverted and removed by means of a screen placed over the sprayed concrete hopper. Fibres shall be uniformly distributed throughout the mortar mix without isolated concentrations. Fibres shall not be added to the mix at a rate faster than that at which they can be blended with the other ingredients without forming balls or clumps.

13.7.7 Preparation of Surfaces

Before sprayed concrete is applied, checking and correction of the excavated cross-section profile shall be carried out. The surfaces to which sprayed concrete is to be applied are to be barred down of all large loose material and the area cleaned down of all loose and foreign material with a mixture of water and air applied at high pressure.

Where the inflow of groundwater renders the surface too wet for the normal application of sprayed concrete, the surface shall be treated as set out in Section 8 – Dealing with water.

All surfaces to receive sprayed concrete shall be moist and free of all traces of dirt, oil, rebound or other deleterious material.

Where sprayed concrete is to be placed over a previous layer, that layer shall be first allowed to reach its initial set and then cleaned of all rebound or other loose material.

13.7.8 Placing

Sprayed concrete shall be placed in accordance with good practice as detailed in AC1-506R-85 Guide to Shotcrete, except that with silica fume sprayed concrete it is usually possible to build up relatively thick layers in a single pass.

No sprayed concrete shall be placed in air temperatures less than 1°C. Where necessary freshly sprayed concrete shall be protected from rain or water until the surface is of sufficient hardness to prevent damage.

The base concrete mix for the wet mix process shall be applied within 1,5 hours from first mixing the component materials. This time may be extended by the use of retarders, plasticisers or hydration control admixtures. Aged concrete shall be discarded.

There shall be no inclusion of rebound in the finished work, no hollow areas and a good adherence to the rock and a reasonably smooth surface finish shall be achieved. Rebound shall be kept clear of sprayed concrete being placed.

The minimum specified layer thickness shall be controlled by depth pins attached to the rock surface and reinforcement, or other suitable means.

Before a succeeding layer is placed the existing work shall be checked for hollow or non-adhering areas and these shall be cut out and replaced.

Construction joints in the layer shall be formed at 45° to the face and precautions shall be taken to prevent weak and unsightly edges at construction joints. If necessary, timber strips may be temporarily fixed in place to give a neat, strong edge. Before placing the adjoining work the existing edge shall be cleaned and thoroughly wetted.

Dust pollution shall be minimised by choice of appropriate equipment and by means of additional ventilation, water sprays, and by maintaining equipment in good order.

13.7.9 Curing

Sprayed concrete shall be cured by a suitable method and in compliance with Section 20.

The use of a sprayed surface curing compound will not be permitted. The sprayed concrete shall be kept moist continuously for 3 days by spraying with a fine mist of water at intervals not exceeding 4 hours. Should it not be practical to keep the sprayed concrete moist for 3 days due to the disruptive effect that this may have on other operations, the Contractor shall give consideration to using an internal curing additive, provided that bonding between different layers of sprayed concrete are not adversely affected by such addition.

Membrane curing shall not be used where a further layer of sprayed concrete is to be applied.

Curing shall ensure that the sprayed concrete exhibits proper strength gain and a minimum of cracking.

13.7.10 Operators for Sprayed Concreting

Only trained and tested operators shall be used for sprayed concreting operations. Each nozzle man and back-up team shall carry out a series of trial applications in the presence of the Engineer to demonstrate their ability in applying sprayed concrete. Test panels as described in Clause 13.7.14 shall be made by each operator. Only the operators whose test panels pass the 28 day crushing strengths shall be allowed to do this work.

13.7.11 Drainage Holes

Where groundwater inflows could interfere with the application of sprayed concrete or cause a reduction in the quality of sprayed concrete, the Contractor shall take action to control such groundwater inflows. Such action shall include the channelling of water by means of pipes and chases.

Where required drainage holes shall be provided in accordance with the provisions of Section 18 – Drilling and Grouting. Where sprayed concrete is applied after completion of the drainage holes the drainage holes shall be extended through the sprayed concrete with suitable formers or similar. Plastic pipes or tubes used for this purpose may be left in holes drilled into the rock and embedded in sprayed concrete.

13.7.12 Pressure Relief Holes

Generally one (1) day after spraying concrete, pressure relief holes of 38 mm diameter shall be drilled through the sprayed concrete and 450 mm minimum into the rock. In general a spacing of 1 hole per 4 m^2 shall be provided in areas where a build-up of water pressure could be expected.

13.7.13 Checking of Applied Thickness

The thickness of applied sprayed concrete shall be checked by the Contractor by means of an agreed grid of test holes. An acceptable procedure for these test holes shall be such that on average in any 100 m^2 of sprayed concrete area at least 10 test holes shall be drilled with a percussion drill.

The basis of acceptance shall be that in any area of 100 m^2 the arithmetic mean thickness of all the points checked shall be equal to or greater than the specified thickness. In addition, at no point shall the thickness be less than 70% of the specified thickness for layers less than 100 mm specified thickness or 50% for layers of 100 mm specified thickness or more. Where the thickness is not acceptable, an additional layer of sprayed concrete to be applied and rechecked for thickness.

13.7.14 Testing

On average, one test panel shall be made and tested by the Contractor on each shift when sprayed concrete is applied in each shaft and each surface location. Such test panels shall be prepared by the nozzle man doing the work during normal sprayed concreting operations. For the first 50 m^3 of

sprayed concrete applied in each heading, test panels shall be prepared and tested for each 10 m^3 applied.

The test panels are to be made by spraying into moulds 750 mm x 450 mm x 200 mm deep with sides splayed outwards at 45° to prevent the entrapment of rebound. Panels shall be placed against the sidewall. Panels shall be clearly marked to identify the time and date of spraying and the area where they were sprayed.

Subject to satisfactory test results the testing frequency may be reduced at the discretion of the Engineer.

13.7.15 Testing of Sprayed Concrete

For acceptance and routine testing, 100 mm diameter cores of a length between 110 mm and 150 mm after the ends are cut and trimmed, shall be drilled from test panels by the Contractor. The remainder of the test panel shall be broken up to provide samples for density testing.

The panels shall be field cured in the same manner as the work, after which the Contractor shall deliver the panels to the laboratory where the panels shall be cured in water as specified in BS 1881.

Three cores shall be cut and tested for compressive strength at 3 days, 7 days and 28 days. The compressive strengths shall be corrected to the equivalent cube strength as set out in BS 1881.

In places where the thickness of the sprayed concrete layers is such that it will be possible to cut out 100 mm test cores, the Engineer may specify that such cores be cut out for testing. An average of not more than 2 x 100 mm cores shall be required for every 100 m^2.

Three samples each shall be tested at 7 days for volume of permeable voids and boiled absorption (density) tests.

For the purpose of sampling and testing sprayed concrete the Contractor shall supply all the panel moulds and core sampling equipment. The concrete testing machine supplied by the Contractor for testing concrete cubes shall also be suitable for testing sprayed concrete samples.

13.7.16 Failure of Sprayed Concrete

For the purposes of routine testing the quality of the sprayed concrete will be considered satisfactory if every test result is at least 80% of the specified result and if at least 80% of all results exceed the specified result.

Should test samples of sprayed concrete not achieve the specified minimum result, additional tests be carried out by the Contractor to determine new mix proportions and/or application methods to avoid further such failures.

If the low test results of the applied sprayed concrete may reduce the safety of the Works and persons or be detrimental to the effectiveness of the support, the following actions shall be taken:

a) Remove the defective sprayed concrete in strips or panels in such a way that the safety of the Works and persons is not endangered and replace with sprayed concrete that is acceptable, which may also require the replacement of the mesh; or
b) Apply additional thickness of sprayed concrete not exceeding the thickness originally required.

13.7.17 Defects and Repairs

Before a subsequent layer of sprayed concrete is placed, the preceding layer shall be checked for defects.

Areas of work shall be properly compacted and bonded and free from segregation, honeycombing, laminations, dry or ‘sandy’ patches, voids, sagged or slumped material, rebound, excessive cracking, single voids with dimensions in excess of 15 mm in any direction, and overspray.

Delamination either within sprayed concrete or at the rock/sprayed concrete interface shall constitute cause for sprayed concrete rejection. The extent of delamination shall be evaluated by sounding with a blunt metal object and, where necessary, verified by coring.

Where a defect is required to be rectified, the area to be replaced shall in any event be not less than 300 mm x 300 mm.

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SECTION 14

SPOIL, BORROW AND EXCAVATED MATERIALS

TCTA MODULAR STANDARDS
SECTION 14
SPOIL, BORROW AND EXCAVATED MATERIALS

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SECTION 14
SPOIL, BORROW AND EXCAVATED MATERIALS

14.1 SCOPE

This Section deals with obtaining borrow materials for the bedding and backfilling of pipelines, fills for embankments, terraces and roadworks and for other use in the Works and spoil of unsuitable or excess material.

14.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

14.2.1 Definitions

a) **"Borrow material"** means any gravel, sand, soil or boulders obtained from designated areas for the construction of the pipelines, embankments, terraces and fills for roadworks. It does not include material obtained from commercial sources.
b) **"Borrow pit"** means the excavated pit within a designated boundary (borrow area), approved for the purpose of obtaining borrow material.
c) **"Spoil"** means excavated material, which is unsuitable for use in the Permanent Works.
d) **"Stockpile"** is material that has been selected, because of its properties, for particular purpose and moved to a designated area into a pile for later use.
e) **"Spoil areas"** means areas within designated boundaries, for the purpose of spoiling unsuitable or excess material.
f) **"Unsuitable material"** is material which does not comply with the specifications.

14.2.2 Abbreviations

AASHTO: American Association of State Highway and Transportation Officials
BS: British Standard
DMR: Department of Mineral Resources
EA: Environmental Authorisation
MHSA: Mine Health and Safety Act
OH&S: Occupational Health and Safety
SANS: South African National Standard
TMH: Technical Methods for Highways

14.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

14.3 OBTAINING BORROW MATERIALS

14.3.1 General

The Contractor shall be responsible for obtaining suitable materials for construction from excavations, designated borrow pits or from other sources. Suitable materials derived from excavations for the Works shall be used in preference to the materials from the designated borrow pits.

Where necessary, crushing and screening equipment shall be made available to ensure compliance of material with the specification.

All borrow pits and spoil areas shall comply to the requirements as prescribed by the regulatory Act (Mineral and Petroleum Resources Development Act, Act 28 of 2002).

14.3.2 Licensing and Negotiations with Owners, Occupiers and Authorities

The necessary licenses, permits and/or agreements for the development, use and rehabilitation of the designated borrow pits shall be obtained by the Employer as required by the relevant legislation. Where the Contractor, at own initiative, plans to obtain materials from alternative borrow areas, he may only use materials from borrow pits that have the necessary licenses, permits and/or agreements in place, and such proof must be submitted to the Engineer. The Contractor shall comply with the conditions of such licenses, permits and/or agreements.

The Contractor to obtain a noise permit from authorities and comply with noise induced hearing loss regulations.

14.3.3 Borrow Pits

Borrow pits shall be established by the Contractor in the designated areas as directed by the Engineer. The information provided in the Contract regarding materials from the borrow areas reflects the results of site investigations and laboratory tests conducted for the Employer.

The Contractor must however investigate these borrow areas by means of test pits and laboratory testing to confirm suitability, prior to borrowing operations. The Contractor shall submit the results to the Engineer in sufficient detail to satisfy him that the quality and quantity of the material available in the proposed borrow area are acceptable for the intended use.

14.4 OPENING AND WORKING BORROW PITS AND SPOIL AREAS

14.4.1 General

All borrow pits and spoil areas shall be managed and rehabilitated in accordance with the conditions of the licenses, permits and/or agreements in this Contract. The Contractor shall be responsible for the opening, working, closing, and rehabilitation of borrow pits and spoil areas.

Prior to commencing borrow and spoil operations the Contractor shall submit, for the Engineer's review, a Method Statement, which shall contain at least the following:

a) Description of access routes to the borrow pits and spoil area, including haul routes to the Works;
b) Position of fences to be erected;
c) Plan for incremental clearing of vegetation, topsoil, overburden and fertile soil to minimise disturbance to the environment;
d) Positions and approximate dimensions of topsoil stockpiles, overburden stockpile and borrow material stockpiles;
e) Positions and approximate dimensions of all working areas required, including crushing and screening and haul road layouts and positions;
f) Mining and backfilling plan;
g) Methods of dealing with storm water, waste water, ground water and any water treatment measures;
h) Dust suppression measures;
i) Noise suppression measures;
j) Final forms, slopes and approximate dimensions of excavation;
k) Survey of original ground levels;
l) Pre-development photographic record of the borrow area; and
m) Rehabilitation measures and landscaping.

Access roads to the borrow and spoil areas shall be established and maintained as part of the operating and management procedure of the borrow pit and spoil areas.

14.4.2 Excavation of Borrow Materials

Borrow material shall be excavated within the limits of depth and area and in a manner that will optimise the use of the available material.

The Contractor shall exercise all reasonable care to avoid contamination of suitable material by the inclusion of unsuitable material.

The creation of vertical walls shall be avoided.

Borrow material shall be excavated in a manner that will minimise any detrimental environmental impacts and in particular:

a) All sensitive areas (i.e. specific flora or archaeological sites) shall be dealt with as per Section 47 and the approved Environmental Management Programme;
b) The handling and stockpiling of topsoil and fertile soil shall comply with the requirements of Section 7- Clearing Site;

c) The Contractor shall ensure the fauna is not disturbed or destroyed during the clearing and mining operations. Any animal life encountered shall be relocated safely to beyond the border of the borrow area;

d) Any natural watercourse shall not be contaminated or polluted during the borrow operations in terms of the requirements of Section 1 - General and Section 8 - Dealing with Water;

e) The Contractor shall implement measures to control dust, noise and visual impacts; and

f) The Contractor shall ensure that during periods when borrow pits or spoil areas is not active, the environmental control measures remain in place.

g) The Contractor shall comply with Construction Regulation 13 when excavating.

14.4.3 Fencing of Borrow Pits and Spoil Areas

Unauthorized access to borrow pits and spoil areas shall not be permitted. Unauthorized access to access roads and the areas occupied by crushing/screening/washing equipment and stockpiles of processed material, shall be prevented by the erection of a temporary fence (5-string barbed wire or game fence) and gates as specified in Section 6 – Fencing. The fence shall be erected prior to commencement of work in the area.

14.4.4 Waste Management

No waste materials as defined in Section 4, other than spoil from excavations, shall be disposed of in the spoil areas.

14.5 FINISHING OFF BORROW PITS AND SPOIL AREAS

All borrow pits and spoil areas shall be rehabilitated in accordance with the licenses, permits and/or agreements in this Contract, including Section 47 – Landscaping and Rehabilitation and the approved Environmental Management Programme.

On completion of operations in a borrow pit or spoil area, the Contractor shall reinstate the entire area so that it blends in with the surrounding area and is suitable for the re-establishment of vegetation. For this purpose, the borrow pit or spoil area shall be shaped to even contours with no slopes steeper than 1: Vertical in 3: Horizontal, except where agreed to by the Engineer, in rocky material or where, in the opinion of the Engineer, it is impractical to do so.

All material in and around the borrow pits or spoil areas, whether spoil from excavations, excess stockpiled material, oversize material, material resulting from clearing and grubbing operations or excess overburden shall be used or disposed of.

Material not capable of supporting vegetation shall be buried and used in shaping the borrow and spoil areas and subsequently be covered with stockpiled soft overburden material. All available overburden shall be spread evenly to suitable thickness. Material to be backfilled in the borrow areas

shall be spread and placed in 500 mm thick layers and compacted to 90% MOD AASHTO. Dumping of solid waste and building rubble will not be permitted in borrow pits or spoil areas.

The finishing off of any borrow pit or spoil area shall be to the satisfaction of the Engineer. The Contractor shall also provide to the Engineer sign-offs by both the Contractor and the landowner, or occupier, discharging the Contractor and the Employer from all further liabilities in respect of any agreements, damage to crops, and borrow pits and spoil areas.

14.6 HAUL ROADS

Only designated haul roads shall be used to access the borrow and spoil areas. The Contractor shall minimise any disturbance to the environment during the construction and use of haul roads. The Contractor shall fence haul roads as part of the Site.

The Contractor shall ensure that haul roads are maintained, including measures to control dust, erosion and speed.

Haul roads shall be scarified and rehabilitated to pre-construction condition or better.

All construction vehicles from the Contractor which includes trucks and machinery, shall travel between 15km/h to 30km/h.

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BACKFILLING AND BEDDING

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SECTION 15
BACKFILLING AND BEDDING

15.1 SCOPE

This Section covers:

a) Bedding and backfilling of trenches and service crossings for all types and sizes of pipes, culverts, site services and electrical conductors. It covers the preparation of a trench bottom, supply, placing and compaction of bedding, backfilling and the reinstatement of surfaces. In the following Clauses references to trenches shall also apply to pits and reference to pipes shall also apply mutatis mutandis to conduits, culverts and cables; and
b) General earthworks, backfilling around all types of structures, the construction of platforms and terracing.

This Section shall be read in conjunction with:

- Section 9 - Bulk Surface Excavations and Trenching;
- Section 14 - Spoil, Borrow and Excavated Materials; and
- Section 16 - Embankment Construction.

15.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

15.2.1 Definitions

For the purposes of this Section the following definitions shall apply:

a) **"Bed"** means the zone in which bedding is placed and compacted over the full width of the trench, to a minimum depth of 200 mm, on which a pipe or duct is placed such that the pipe is uniformly supported over the entire length of the pipe.
b) **"Bedding cradle"** means the zone above the Bed in which bedding is placed firmly without voids under and up both sides of a pipe or duct such that the pipe is uniformly supported over an arc length of 120^{o}, up to the underside of the Selected Fill Blanket.
c) **"Selected fill blanket"** means the zone above the Bedding Cradle in which material is placed and compacted to form a blanket around the pipe on or from the top of the Bedding Cradle up the sides and 300 mm over the top of a pipe, duct, or cable, in such a manner that the barrel of the pipe, duct, or cable is supported continuously and protected over the top by a dense cushion of Fill Blanket material.
d) **"Bedding material"** means the material placed in the Bed, Bedding Cradle or Selected Fill Blanket.
e) **"Main backfill"** means the suitable filling material placed and compacted in the pipe trench after the pipe has been laid, bedded and surrounded by the completed Selected Fill Blanket.
f) **"Flexible pipe"** means a pipe of which the diameter is reduced by more than 1% under an external radial force before the appearance of cracks.

g) **"Joint hole or Fox hole"** means a depression formed in the bed and trench bottom to accommodate a joint or pipe stiffeners in a pipeline. The Joint Hole shall be large enough to allow adequate working space to perform welding of the pipe joint and to apply (and repair if necessary) the corrosion protection of the pipe over the welded pipe joint section.

h) **"Rigid pipe"** means a pipe, the diameter of which is reduced by not more than 1% under an external radial force before the appearance of cracks.

i) **"Excavation profile''** is the initial assumed excavation profile at design and tender stage, interpreting and taking account of the available data regarding the prevailing geotechnical conditions.

The purpose of this assumed excavation profile at design and tender stage is to:

- perform a realistic and comparative mass balance calculation;
- check construction production rates;
- check excavation price adjustment for use of vertical payment lines; and
- check constructability from an available working space and safety allowance perspective.

The Contractor shall be responsible for all lateral support and the safe-guarding of all excavations, and all costs involved with the proper safeguarding of the excavations and this shall be included in the tender prices.

j) **"Compaction moisture content"** means the range of moisture content between –1% and +2% of the optimum moisture content determined for the respective soil samples.

k) **"Soilcrete"** means a flowable mixture of soil, cement and water that is used as a bedding cradle to provide uniform support to the pipe and achieve a minimum compressive strength of 200 kPa at 7 days and a minimum compressive strength of 700 kPa at 28 days.

l) **"Embankment"** means an earthworks structure constructed using Fill.

m) **"Foundation for embankment (or terrace)"** means the natural in-situ material on which the Embankment (or Terrace) is to be constructed.

n) **"Fill"** means the earthworks constructed on the Foundation for Embankment (or Terrace) for the construction of earthworks, an Embankment or Terrace.

o) **"Selected fill"** means the upper layer or layers of the Embankment or Terrace (also referred to as **Selected layers**) which are controlled both in quality and density by requirements more stringent than those for Embankments (or Terraces) in general.

p) **"Structure backfill"** means the suitable material placed and compacted against structures as backfilling or fill.

q) **"Roller passes''** An area will be taken to have received one roller pass when a roller has passed over such an area once. Additional passes made only as a result of overlapping so as to ensure full coverage shall not be taken into account.

r) **"California bearing ratio"** The California Bearing Ratio (CBR) of an untreated soil or gravel as determined by means of Method A8 of TMH1 is the load in Newtons, expressed as a percentage of California standard values, required to allow a circular piston of 1 935 mm² to penetrate the surface of a compacted material at a rate of 1.27 mm per minute

to depths of 2.54, 5.08 and 7.62 mm. The California standard values for these depths are 13.344, 20.016 and 25.354 kN respectively.

15.2.2 Abbreviations

AASHTO: American Association of State Highway and Transportation Officials
ASTM: American Society for Testing Materials
BS: British Standard
CBR: Californian Bearing Ratio
CEM: Calcium Enriched Mixture (Cement)
COLTO: Committee of Land Transport Officials
CSIR: Council for Scientific and Industrial Research
EN: European Norm
GM: Grading Modulus
LL: Liquid Limit
LS: Linear Shrinkage
MDD: Maximum Dry Density
OMC: Optimum Moisture Content
PI: Plasticity Index
PMB: Polymer Modified Bitumen
SANS: South African National Standard
TMH: Technical Methods for Highways
TW: Tape Wrapping

15.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHS Act 85 of 1993, Construction Regulation 2014 and Construction Regulation 13 when excavating and trenching.

15.3 MATERIALS

15.3.1 Classes of Excavation

The excavation of material will be classified as specified in Section 9 – Bulk Surface Excavations and Trenching.

15.3.2 Bedding Material

Bedding Material for flexible pipes shall be material complying with the criteria in Table 15/1.

TABLE 15/1
BEDDING MATERIAL TYPE

BEDDING MATERIAL TYPE	BEDDING ZONE (Note 1)	USC CLASSIFICATION	ADDITIONAL REQUIREMENTS (Note 3)	SOIL DESCRIPTION
SC1	Bed, Bedding Cradle, Selected Fill Blanket	SW, SP, GW, GP or any soil type beginning with one of these symbols	12% or less passing the No. 200 sieve (0.075 mm)	Clean coarse-grained soils
SC2	Bed, Bedding Cradle, Selected Fill Blanket	GM, GC, SM, SC or any soil type beginning with one of these symbols	More than 12% passing the No. 200 sieve (0.075 mm)	Coarse grained soils with fines

Notes:

1. Maximum particle size for all Bedding material is 9.5 mm, except for Polymer Modified Bitumen (PMB - e.g. Bituguard) or Tape Wrapping (TW) pipe coatings where the maximum particle size for all Bedding material is 3.0 mm. This requirement is applicable to all buried pipe sections (pipes, pipe specials and fittings, pipe joints etc.) with PMB or TW coating.
2. A-3 and A-2-4 material (based on AASHTO Classification) shall not be placed and worked in wet conditions nor be allowed to become saturated before it has been placed in position and compacted. If the material has dried out before it is covered, the top surface could break down during activities on the surface and the material shall then be reworked to achieve the specified density.
3. All material to be free of vegetation and other organic material to a standard acceptable to the Engineer.

15.3.3 Main Backfill Material

Material excavated from trenches shall be used as Main Backfill in all areas, provided it contains little or no organic material, it excludes boulders of dimension exceeding 150 mm and can be placed without significant voids and compacted as to avoid significant settlement.

In areas subject to loads from road traffic and in other areas as directed by the designer or Engineer, Main Backfill shall have a PI not exceeding 12 and a minimum CBR of 15% at specified density if the backfill is to be placed in the upper 150 mm of the road subgrade and a PI not exceeding 12 and a minimum CBR of 7% if the backfill is to be placed lower in the road subgrade.

15.3.4 Soilcrete for Pipe Bedding

Soil for soilcrete shall be selected from the trench excavations or, if no suitable soil is available from that source, imported from a borrow area (if any). The material shall be a fine, sandy or clayey-sand soil with a plasticity index of not more than 10 and shall comply with the grading requirements in Table 15/2.

TABLE 15/2
SOILCRETE MATERIAL TYPE

SCREEN SIZE (mm)	PERCENTAGE BY MASS PASSING SCREEN
9,50	100
0,075	<25

Note:
Maximum particle size for all material types is 9.5 mm, except for Polymer Modified Bitumen (PMB - e.g. Bituguard) or Tape Wrapping (TW) pipe coatings where the maximum particle size for all material types is 3.0 mm. This requirement is applicable to all buried pipe sections (pipes, pipe specials and fittings, pipe joints etc.) with PMB or TW coating.

Cement for soilcrete shall be Portland cement CEM I 42,5, 42,5R or 52,5 or a combination of these cements which shall comply with the latest requirements of SANS EN 197-1. Cement shall be delivered to the Site in a dry condition undamaged by exposure to the weather and shall be stored on the Site in suitable weather and damp-proof conditions.

The soilcrete shall be designed to produce a flowable mix that will flow freely into the trench or formwork and under the pipe without segregation and which, in addition, will attain the specified compressive strengths and have low drying shrinkage.

The proportions of soil, cement and water shall be based upon laboratory tests made with the soil, cement and water to be used on the work. The tests shall have at least three different water contents, the flow consistency, 7-day and 28-day compressive strengths and the drying shrinkage. It is envisaged that the cement contents will vary between 4% to 5% of the mix, by mass.

The flow consistency of the mix shall be tested in accordance with the requirements of the latest edition of ASTM D6103-17. A guide flow consistency for the laboratory mix is a spread diameter of 200 mm. Based on the laboratory tests and field trials a suitable range of flow consistency shall be specified as part of the design. The site mix shall be sampled and tested by the Contractor prior to and at the point of placement in the trench. Any batch not complying with the specification shall be removed from Site or disposed of.

The compressive strength shall be determined from 150 mm cubes sampled at the point of placement. The Contractor shall sample a minimum of 6 cubes per placement lift. After filling the cube moulds with the soilcrete mix, the top surface shall be sealed with a non-porous plate. Once the initial set has taken place the top plate shall be removed and the filled cube mould placed in a sealed plastic bag and stored on Site between 20°C to 25°C until required for testing. Testing shall take place at an accredited laboratory with the testing machine and test method that comply with the latest requirements of ASTM D4832-16 Ed. The soilcrete compressive strength shall be a minimum of 200 kPa at 7 days and a maximum of 700 kPa at 28 days.

The drying shrinkage shall be determined from samples prepared using the 280 mm x 50 mm x 50 mm moulds specified in the latest edition of SANS method 836. Soilcrete samples of the required

flow consistency shall be oven-dried to constant mass and the linear shrinkage of each sample reported to the nearest 0.1%. The site mix shall be sampled by the Contractor prior to and at the point of placement in the trench. A minimum of 6 samples per placement lift shall be collected and tested in the laboratory.

All soilcrete shall be batched and mixed under the supervision of a competent and experienced person. The quantity of water used in each batch of soilcrete shall be carefully adjusted to maintain the required flow consistency for the site mix. Allowance shall be made for the moisture content of the soil which shall be determined either by weighing and drying or other suitable methods. All soilcrete shall be thoroughly mixed and the whole of each batch shall be uniform, free of lumps and free from segregation.

Soilcrete shall be transported to and placed in the trench using suitable equipment to avoid segregation, and to ensure proper flow underneath the pipe. The Contractor shall take all necessary precautions to avoid pipe floatation such as placing the soilcrete fill in more than one layer.

15.3.5 Fill

Fill material for general earthworks, embankments and terracing shall be natural material (soil, sand or gravel) and conform to the requirements specified below:

a) The completed Fill shall contain no rocks or stones greater than two thirds of the layer thickness;
b) Hard or rock material shall have a maximum dimension of 300 mm;
c) Maximum Plasticity Index shall be 18; and
d) Minimum California Bearing Ratio (CBR) at specified in-situ density:
    - Depth below top of fill, 0 m to 1.2 m Minimum 3% at 90% of Modified AASHTO
    - Depth below top of fill, 1.2 m to 9 m Minimum 3% at 100% of Modified AASHTO

15.3.6 Selected Fill

Selected Fill material for general earthworks, embankments and terracing shall be natural material (soil, sand or gravel) and conform to the requirements specified below:

a) The completed Selected Fill shall contain no rocks or stones greater than two thirds of the layer thickness;
b) Hard or rock material shall have a maximum dimension of 300 mm;
c) Minimum CBR at 93% Modified AASHTO maximum dry density shall be at least 15%;
d) Maximum Plasticity Index of 12, unless otherwise approved by the Engineer (the Engineer shall have the right to alter the latter requirement to 3 times grading modulus + 10);
e) Minimum grading modulus of 0.75 and maximum grading modulus of 2.7; and
f) Maximum swell of 1.5% at 100% Modified AASHTO density.

In-situ material falling within the Selected Fill horizon shall, when not conforming to the requirements for Selected Fill material, be excavated and replaced with Selected Fill material.

15.3.7 Structure Backfill

Material placed as backfill or as fill against structures shall comply with the requirements of Fill materials specified in this Section, except that backfill within 1 000 mm of structures shall not contain more than 10% rock or hard fragments retained on a sieve of nominal aperture size of 50 mm and shall have a maximum dimension of 100 mm.

15.3.8 Selection of Material

15.3.8.1 General

The Contractor shall not dispose of excavated material suitable for re-use unless it is surplus to the requirements of the Contract.

The Contractor shall excavate and stockpile material in such a way that material suitable for re-use are kept separate. He shall take the necessary steps to avoid burying or contaminating materials which otherwise would be suitable for re-use.

When material otherwise suitable for re-use from excavations is contaminated, the Contractor shall, to make up any shortfall, obtain (at his own expense if the contamination is due to his actions) suitable material from other excavations on the Site, or by opening up borrow pits, or by importing from commercial or other sources.

Stockpiled materials shall be arranged so as to not obstruct the Works, traffic or drainage. Surplus material not required for re-use and re-instatement shall be removed to designated spoil dumps during the progress of the work.

15.3.8.2 Pipelines

The Contractor shall not dispose of excavated material that complies with the requirements for Bedding Material and Main Backfill unless it is surplus to the requirements of the Contract.

The Contractor shall excavate and stockpile material in such a way that the various constituents for use as topsoil, fertile soil, Bedding Material and Main Backfill are kept separate. He shall take positive steps to avoid burying or contaminating materials which otherwise would be suitable for use as:

a) Bedding Material unless other materials have been specified;
b) Topsoil;
c) Fertile soil; or
d) Materials for re-use elsewhere on Site.

15.3.9 Suitable Material Not Available

Where suitable material (Bedding Material, Main Backfill, Fill or Selected Fill, etc.) is not readily available from trench excavation or designated sources on Site, or from other excavations for the Works in each instance obtain suitable material from the following sources to replace the shortfall:

a) From screened, washed or other treated excavated material;
b) From other excavations on the Site;
c) By importing from specified borrow pits (if any); or
d) By importing from commercial or other sources.

15.4 CONTRACTOR'S EQUIPMENT

15.4.1 Control of Water

The Contractor shall use appropriate techniques or equipment such as pumps or well points for keeping the earthworks, excavations, embankments, terraces and trenches sufficiently free from water to enable him to construct the Works and to lay pipes true to line and level and to bed them soundly, all as specified in Section 8 – Dealing with Water.

15.4.2 Compaction Equipment

Equipment shall be suitable for the production of the end result required under the conditions applicable to the Site.

Compaction equipment used for applying the dynamic load, controlling the moisture content, and grading or mixing, shall be capable of achieving the compaction specified with the materials available for the construction of the Works.

For pipelines, ducts or cables, the Contractor may use mechanical compaction equipment but he shall select such equipment and operate it in such a manner that the pipeline, duct or cable is not unduly stressed, damaged or deformed. Heavy machine compaction shall not be used directly above the pipe until sufficient backfill has been placed to ensure that machine compaction loads transmitted to the top of the pipe are no greater than would be imposed by normal road traffic over a pipeline with cover of depth 800 mm.

15.5 CONSTRUCTION (PIPELINES)

15.5.1 Bedding and Backfilling for Pipelines

a) The bottom of the trench shall be prepared as specified in Section 9.
b) The Contractor shall not place any bedding material on the excavated trench bottom, or continue to any new stage of backfilling until the prepared trench bottom or the surface of the underlying zone has been inspected and accepted by the Engineer. The Contractor shall advise the Engineer whenever sections of trench have been excavated and trimmed, and when backfilling of a certain zone has been completed and is ready to receive the next layer.
c) Trenches shall be backfilled as soon as possible after pipe laying to limit:

i) Thermal movements of the pipeline causing stress concentrations;
ii) Mechanical damage to coatings;
iii) Damage to the pipeline due to flotation should the trench fill with water; and
iv) Safety risks.

The restrictions in the following table shall apply:

TABLE 15/3
MAXIMUM LENGTH OF OPEN TRENCHES

NUMBER OF PIPES LAID PER DAY (Note 1)	**PRODUCTION RATE** (Note 2)	**MAXIMUM EXPOSED LENGTH** (Note 3)
3	54 m – 57 m / working day	400 m
4	72 m – 76 m / working day	550 m
5	90 m – 95 m / working day	700 m

Notes:
1. Pipe lengths vary between 18 m and 19 m
2. Average rate of progress of the train of all sequential pipe installation/construction processes
3. Length of open trench measured ahead of Selected Fill Blanket.

The maximum lengths of open trench in Table 15/3 shall be reduced if required by the relevant policies of insurance.

d) In dealing with water as required in terms of Section 8 – Dealing with Water, the Contractor shall, subject only to such particular items as are scheduled for designated hazards, properly and adequately protect the Works from flooding and damage by storm water, flow from springs and seepage. The Contractor shall take every precaution to prevent water from any source entering the excavations and shall keep the pipe trench free from water while carrying out excavation, preparation of the trench bottom, placing the pipe bed and until the trench is backfilled to the level below the top soil.
e) No timber or other organic materials shall be left in the excavation during backfilling without the agreement of the Engineer.
f) In built-up areas, barricades shall be clearly visible at night time and equipped with red warning lights.

15.5.2 Pipe Bed and Bedding Cradle

15.5.2.1 Pipe Bed

a) As soon as the trench bottom has been inspected and accepted by the Engineer, the bedding material for the pipe Bed shall be placed and compacted to the level and grade as specified over the full width of the trench. Where the cradle consists of soilcrete and the pipe is supported on sandbags, the thickness of the bed shall be reduced to 80 mm minimum to compensate for the difference in procedure.
b) The pipe shall be uniformly supported along its length at the required level and grade without interfering with the placement and compaction of the balance of the bedding material.
c) The Contractor shall excavate holes for joints, stiffeners and pipe lifting bands and the trench shall not be considered ready for pipe laying until the pipe Bed and Joint Holes have been constructed by the Contractor and accepted by the Engineer.
d) Where the trench bottom is too soft and waterlogged to permit placement and compaction of bedding material in the normal manner, the trench bottom shall be further excavated and a layer of crushed stone placed as specified in Section 9. The pipe Bed material shall then be placed as described.

15.5.2.2 Bedding Cradle

a) After a pipe section has been placed in position and the joint completed, placing of the Bedding Cradle shall commence.
b) During the placing of the Bedding Cradle, bedding material shall be placed and compacted in layers evenly on both sides of the pipe. During compaction the material shall be watered to optimum moisture content and compacted in layers not exceeding 150 mm in depth, to densities specified in this Section.
c) The material in the ‘wedges’ formed by the curvature of pipe bottoms shall be compacted by hand punning horizontally and obliquely, and the layers by pneumatic rammers or vibratory rollers. Whatever method is adopted, great care shall be exercised at all times to prevent damage to pipe coatings or disturbance of the pipe level and grade by upward forces, flotation or otherwise.
d) If soilcrete is specified for the Bedding Cradle, the pipe shall be supported on sandbags placed on the prepared Bed underneath each pipe to elevate the pipe bottom about 120 mm above the Bed. The Contractor shall ensure that the pipe is properly supported on the sandbags. A minimum of 4 support positions per pipe shall be provided, evenly spaced along the pipe and on both sides of the pipe, and to the dimensions specified by the coating supplier.
e) The soilcrete shall be placed in at least two consecutive lifts to prevent pipe flotation. It shall flow through the cavity underneath the pipe providing continuous support to the pipe. The Contractor shall allow the soilcrete to set sufficiently to gain enough strength (not less than 2 days after placing) to allow placing of the Selected Fill Blanket to commence.

15.5.3 Selected Fill Blanket

a) Placing of the Selected Fill Blanket shall only proceed after acceptance of the Bedding Cradle by the Engineer.
b) The Selected Fill Blanket shall be placed in layers not exceeding 150 mm depth in the loose, watered to optimum moisture content and compacted evenly in layers on both sides of the pipe to densities as specified. Compaction may be undertaken by pneumatic rammers or vibratory rollers. Whatever method is adopted, great care shall be exercised at all times to prevent damage to pipe coatings or disturbance of the pipe level and grade by flotation or otherwise.
c) The top of the completed Selected Fill Blanket shall be formed to an even surface prior to commencement of the Main Backfill.

15.5.4 Main Backfill

a) After completion of the Selected Fill Blanket, the remaining trench depth shall be filled with excavated material or imported material specified in this Section . The Main Backfill in the trench shall be placed in layers not exceeding 200 mm loose in depth and compacted in accordance with Clause 15.7 up to the underside of the fertile soil. The remainder of the trench shall be completely filled with fertile soil and topsoil, the volumes and thicknesses being similar to what were originally removed. It shall be loosely compacted as specified. The top of the topsoil may be mounded to 150 mm or to the thickness as per the pre-construction survey (whichever is greater) above surroundings ground level to provide for settlement, care being taken to reinstate the drainage measures as described below.
b) Where backfilling is carried out by mechanical equipment, heavy equipment exceeding the allowable design traffic load on the pipe shall not be allowed to travel along or across the trench.
c) As soon as trench backfilling has been completed over any portion of the pipeline, all surplus material and debris shall be removed from the servitude area to a dumping site approved by the Engineer. Precautions shall be taken to ensure that the natural drainage of the ground is not interfered with, especially where topsoil or final backfill is left mounded. All necessary cross drains shall be constructed and agricultural drainage berms and contours reinstated as backfilling progresses. Care shall be taken to prevent erosion of backfill by construction of the necessary cross drains and drainage berms.
d) The Contractor shall be responsible for repairing any settlement of backfill and erosion of the servitude up to the end of the Defects Notification Period. He shall fill and level any settlement and/or erosion from time to time, to a standard acceptable to the Engineer and at the Contractor’s expense.

15.5.5 Cleaning of Pipeline Servitudes

As soon as possible after the Main Backfill has been completed, the Contractor shall clean the pipeline servitude of all surplus materials and debris and disposal shall be in accordance with the Contract. The cleaning of the servitude shall not lag behind the pipe laying operation by more than 500 m. Should this happen the Engineer reserves the right to stop the pipe laying operation.

15.5.6 Gravel Road Crossings

In areas subject to road traffic loads, trenches shall be backfilled in layers of thickness (after compaction) not exceeding 150 mm and the Main Backfill shall be compacted to 93% minimum of modified AASHTO maximum density in the case of cohesive soil or 98% minimum in the case of non-cohesive soil.

Immediately after completion of the Main Backfill to the top of the road subgrade level of a trench that crosses or runs along a gravel road, the Contractor shall reinstate the road surface by filling the remainder of the trench with a well-graded and well-compacted hard-wearing gravel surface of thickness at least 150 mm and of quality equal or better to that of the existing road surface.

The gravel layer may be finished with a slight camber in order to allow for initial settlement but, particularly where the new gravel surface is transverse to the flow of traffic, shall not be left so far proud of the adjacent road surface as to cause excessive jolting of any vehicle proceeding at normal speed.

15.5.7 Concrete Encased Sections

Pipe sections crossing underneath rivers, streams, wetlands and roads (excluding pipe jacking sections) shall be fully encased in reinforced concrete, unless otherwise allowed by the Engineer. Trench foundations shall be designed to accommodate concrete encasements without any settlements. The pipe laying procedure shall be as described below:

a) In the event of wet trench conditions, a drainage system as described in Section 9 shall be provided.
b) An in-situ concrete screed of approximately 35 mm shall be placed on the trimmed bottom of the trench. This shall be followed by a 450 mm deep concrete bed, following placing of reinforcing
c) The pipe section shall not be placed within 24 hours of casting of the concrete bed. Sufficient space within the concrete bed shall be allowed for welding and application of the outer coating of the pipe joints. These spacers shall be filled with concrete after completion, testing and acceptance of the welds.
d) Care shall be taken to ensure that the pipes do not move during welding.
e) Suitable formwork and the necessary precautions to prevent flotation during concreting operations shall be provided. Methods adopted to prevent flotation shall not damage coatings or linings. Any damage to the pipework shall be repaired.
f) Prior to the placing of concrete, the Contractor shall inspect and ensure that no reinforcement is in contact with the pipeline and that any damage to the pipeline coating has been repaired.
g) The concrete for the encasing shall be placed in such a way that all spaces under and around the pipe are completely filled. The concrete cover over the crown of the pipe shall be a minimum of 300 mm. Concrete casing shall be cast in one continuous operation until

completed. No part of the concrete casing shall be closer than the maximum of 150 mm or one coupling width to any flexible joint in the pipeline.

h) No backfill over the concrete shall commence until at least 7 days after the concrete has been placed or until the concrete has attained a strength of at least 10 MPa.

i) Hydrostatic testing of these pipe sections shall be undertaken after concrete encasement and will form part of the main pipe testing activities.

15.6 CONSTRUCTION (GENERAL EARTHWORKS, EMBANKMENTS, TERRACING AND STRUCTURE BACKFILL)

15.6.1 Placing and Spreading of Fill Material

Upon completion of the foundation treatment, materials required for the Fill layer concerned shall be deposited in place and prior to compaction shall be evenly spread over the whole of the designated area. The material shall be placed in such quantity that the thickness of any one layer, when measured after compaction, shall comply with the requirements specified or as established by trials conducted by the Contractor as agreed with the Engineer. Any new layer of less than 75 mm in compacted thickness shall be bonded to the previous layer by scarifying the previous layer to a depth of not less than 25 mm or to such greater depth so that the total compacted thickness of the new layer plus the scarified portion of the previous layer will not be less than 100 mm.

15.6.2 Construction of Fill near Structures

Where it is necessary to place Fill around structures forming part of the Permanent Works, it shall be placed and compacted evenly on all sides to minimize unbalanced loads on such structures. Such Fill shall not contain boulders or any other hard material, which, in the opinion of the Engineer, may result in damage to the structure or incomplete compaction of the Fill.

Backfilling against water retaining structures will only be permitted after completion of testing for water tightness of the structure.

At all Fills adjoining unfinished structures, such as retaining walls and large culverts, where the construction of the Fill or backfilling behind the structure cannot be undertaken simultaneously, the Fill shall be constructed in such a manner that the longitudinal slope of the surface of the Fill at any stage forms a continuous plane sloping towards the structure with a gradient not exceeding 10%. When the structure is completed, the remaining portion of the Fill shall be completed in a similar manner except that no heavy compaction equipment shall be used within 3.0 m of the structure. Backfilling of the structure shall be undertaken at the same time maintaining the backfill behind the structure at the same elevation as the adjoining Fill. No additional payment shall be made for constructing Fill in this manner.

15.6.3 Construction of Structure Backfill

Backfill within 1 000 mm of structures shall be considered as Structure Backfill. Structure Backfill shall be placed in loose layers not exceeding 300 mm and compacted evenly on all sides of the structure to minimize unequal loading on the structure. Such Structure Fill shall not contain boulders or any other hard material which, in the opinion of the Engineer, may result in damage to the structure or incomplete compaction of the Structure Backfill.

Where the use of conventional compaction equipment close to a structure is not possible, the material to be compacted shall be placed in loose layers of thickness not exceeding 200 mm and compacted by means of mechanical tampers to at least the density specified for the particular Structure Backfill.

15.6.4 Preparation of Material

15.6.4.1 General

All material used in the construction of any earthworks layer shall be reduced to the specified maximum permissible sizes during excavation by cross ripping, secondary blasting or other suitable means if necessary, before any breaking down as described below is attempted.

In order that earthworks layer thicknesses are not dictated by the presence of isolated larger rocks, the Engineer may order that material which cannot be broken down to the size generally obtainable for the rest of the material in the layer, be removed and disposed of.

The material placed shall be thoroughly broken down throughout the layer by means of equipment suited to this purpose, including grid rolling as specified in this Section. During such processing the layer shall be frequently bladed to bring oversize material to the surface to facilitate breaking down.

In order that earthworks layer thicknesses are not dictated by the presence of isolated larger rocks, the material which cannot be broken down to the size generally obtainable for the rest of the material in the layer, must be removed and disposed of as agreed with the Engineer.

When grid rolling cannot effectively break down the material to the required size, specialised equipment such as heavy vibrating grid rollers and self-propelled tamping rollers, shall be used in order to break down the material.

The material shall be broken down to a size not exceeding two thirds of the layer thickness in the case of Fill and Selected Fill layers.

Where the coarse and fine fractions of the material are not uniformly distributed or have been allowed to become segregated, the material shall be thoroughly mixed on the surface by blading in successive cuts over the full depth of the layer with a motor grader, after the required amount of

water has been added as specified in this Section. Such mixing shall continue until a uniform mixture of the various size fractions of the material has been obtained.

15.6.4.2 Grid Rolling

A cycle of grid rolling shall be taken to mean the following:

a) The material shall be spread on a hard formation surface from the material heaps or windrow into a thin layer (maximum thickness of 50 mm);
b) Rolling shall be carried out with a grid roller of mass at least 13t, the knuckles in a good condition and travelling at a speed of at least 12 km/h, so that every portion of the layer is covered by four passes of the roller;
c) The material shall be windrowed to the opposite side of the road or to the next blade width on terraces; and
d) The process shall be repeated until all the material has been windrowed to the opposite side of the road or next blade width to the edge of the terrace. The material shall be checked for oversize and the oversize material removed or broken down by hand.

If the quantity of oversize material after a cycle of grid rolling is more than 5% by volume of the material in the layer, the above shall be repeated or the oversize material be spoiled.

15.6.5 Oversize Material

The Contractor shall exercise all reasonable care not to bring onto the Fill, material which cannot be broken down to the required size by processing on the Fill. This shall be avoided by proper selection in excavation or in borrow pits. Where such material is brought onto the Fill the Contractor shall, at his own cost, remove such material and dispose of it as agreed with the Engineer.

15.6.6 Watering and Mixing

Any water required before the material is compacted shall be added to the material in successive applications by means of water tankers fitted with sprinkler bars or by means of pressure distributors all capable of applying the water evenly and uniformly over the area concerned.

The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and until a uniform mixture is obtained. Thereafter compaction may proceed.

The amount of water to be added shall be sufficient to bring the material to the optimum moisture content for the compaction equipment used and the density required, provided always that compaction shall not be attempted and will not be acceptable with materials not having “compaction moisture content” as defined in this Section. Should the material be too wet, due to rain or any other cause, it shall be harrowed or ripped and allowed to dry out to a moisture content conforming to the above requirements before compaction proceeds.

15.6.7 Compaction

15.6.7.1 Layer Compaction

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned and the length of any section of a layer being compacted shall, wherever possible, be not less than 150 m nor more than can be properly compacted with the Contractor's equipment.- ensuring that the required/specified densities are obtained without damaging lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed.

The compacted layers shall be adequately drained and shaped to prevent water from standing on or scouring the finished work. Windrows shall be removed to facilitate drainage of water from the surface.

No material for a succeeding layer shall be placed if the underlying layer is softened by excessive moisture.

15.6.7.2 Rockfill processing and compaction

During the spreading and compaction process the material shall be compacted and broken down by means of grid or other suitable rollers and shall finally be compacted by means of vibratory rollers in accordance with the formula given below, in order to achieve a good mechanical interlock of the rock and a maximum compaction of the finer material in the interstices between the rock. The type of vibratory roller used, the operating speed, number of passes and the layer thickness shall be governed by the following formula:

$$\frac{Pe.n}{h.V} \quad = 1\,500 \text{ (minimum)}$$

Where: Pe = total static and dynamic force per metre width, exerted by the vibratory roller at operating frequency and amplitude as given by the manufacturer (kN/m)

n = number of passes required

h = compacted layer thickness in metres

V = roller speed in metres per second

Operating frequencies shall be limited to between 20 and 30 Hz, the minimum operating amplitude shall be 1.6 mm, the maximum speed shall be 4 km/h and Pe shall not be less than 120 kN/m.

15.6.8 Finishing of Slopes and Surfaces

15.6.8.1 Slopes

Fill slopes shall be finished to neat lines with all loose rocks and un-compacted material removed. The degree of finish shall depend on the nature of the material used for the Fill slopes but it shall be as smooth as is consistent with the material involved and good workmanship. Boulders shall not be allowed to project out of the Fill or slope surface.

15.6.8.2 Surfaces

The final layer of the Fill shall be uniform and smooth and shall present a hard compact appearance free from elevations and depressions. The top surface of a Fill is to be graded to a cross fall of 2% to prevent the formation of pools of standing water.

15.6.9 Protection of Fills

During construction, the Fill shall be kept well drained and protected at all times. All windrows shall be cut away after construction in order to prevent concentrated water flow on completed Fill layers, but where necessary flat berms shall be constructed to prevent undue erosion of Fill slopes. All permanent drains shall be constructed as soon as possible, plus sufficient additional temporary drains as may be necessary to protect the Fill, and they shall be maintained in good working order. Ruts and potholes developing in the Fill after completion shall be repaired, and damaged sections of the Fill shall be reshaped and re-compacted without additional payment.

All Fill slopes shall be maintained by the Contractor until the issuing of the Taking over Certificate. All erosion and flood damage to slopes shall be promptly repaired. Side drains discharging from cuts and all other drains shall be constructed in such a way that damage to Fill by erosion is avoided.

Proper precautions and temporary measures shall be taken in all cases in order to ensure that the method or procedure by which the Fill is constructed will not impose loads on structures, especially on unfinished structures, which may damage or overstress such structures.

Where the top surface of a Fill is to remain permanently uncovered it shall, be graded to a cross fall of 2% to prevent the formation of pools of standing water.

15.7 COMPACTION

Compaction of all material shall be done at “compaction moisture content” as defined in this Section.

The compaction of the Bedding Material shall be at least 90% of Mod AASHTO (T-180) maximum dry density.

The compaction for the Main Backfill, fertile soil and topsoil shall be to a density of at least 90% Mod AASHTO (T-180) maximum dry density. Compaction of the main backfill in road reserves shall be 90% Mod AASHTO (T-180) maximum dry density.

Fill for general earthworks, embankments and terracing material shall be compacted to at least 90% Mod AASHTO (T-180) maximum dry density. Sands, being for the purpose of this requirement specified as non-plastic sand with not less than 95% passing the 4.75 mm sieve, shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

Selected Fill for general earthworks, embankments and terracing shall be compacted to at least 93% Mod AASHTO (T-180) maximum dry density. Non-plastic sand shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

Structure Backfill shall be compacted to at least 90% Mod AASHTO (T-180) maximum dry density. Non-plastic sand with not less than 95% passing the 4.75 mm sieve, shall be compacted to a minimum in-situ dry density of 100% Mod AASHTO (T-180).

The Contractor shall control the field compaction densities by means of the sand displacement method or any other method (e.g. nuclear density testing) as agreed with the Engineer.

15.8 TOLERANCES

15.8.1 Pipelines

15.8.1.1 Alignment and Grade

Deviation from the specified level of the invert and the specified dimensions of a trench and (for a height equal to at least the diameter of the pipe, culvert or duct, as applicable) of the lower part of the sides of the trench shall be such that the pipe may be laid and bedded in the trench within the tolerances specified for the pipeline.

15.8.1.2 Compaction Densities

At least 4 relative density determinations per density test shall be taken in the case of pipe Bed, Bedding Cradle, Selected Fill Blanket and Main Backfill. After outliers have been examined and replaced, density test results shall conform to the minimum values given in Table 15/4.

TABLE 15/4
DENSITIES AND SAMPLE SIZES

PRESCRIBED COMPACTION	UNIT OF MEASUREMENT	MINIMUM AVERAGE RELATIVE COMPACTION DENSITY PER TEST (4 DENSITY DETERMINATIONS AT LEAST)	MINIMUM VALUE FOR ANY SINGLE DENSITY DETERMINATION FOR THE FOLLOWING NUMBER OF DENSITY DETERMINATIONS					
			4	5	6	7	8	9
85%	**Mod. AASHTO density**	85.1	81.4	81.2	81.0	80.9	80.8	80.7
90%	**Mod. AASHTO density**	90.1	86.4	86.2	86.0	85.9	85.8	85.7
93%	**Mod. AASHTO density**	93.1	89.4	89.2	89.0	88.9	88.8	88.7
95%	**Mod. AASHTO density**	95.1	91.4	91.2	91.0	90.9	90.8	90.7
98%	**Mod. AASHTO density**	98.1	94.4	94.2	94.0	93.9	93.8	93.7

15.8.2 General Earthworks, Embankments and Terracing

15.8.2.1 Elevation

At least 50 elevation measurements shall be taken according to a stratified random pattern of each section of the completed Fill, and the specified levels shall then be determined. Outliers shall be identified and examined.

The lot will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90% of the level measurements show a deviation from the specified elevations which is smaller than 25 mm. Isolated spots, where the surface elevations deviate by more than 30 mm from the specified elevations, shall be repaired to bring the deviation to within 25 mm.

15.8.2.2 Width

a) Fill and Selected Fill: The horizontal measurement taken from the centre line of the Embankment or Terrace to the side of the Embankment or Terrace, shall deviate nowhere by more than 125 mm from the specified dimension when measured at any level.
b) Cut slopes: The cut slopes shall be finished to a standard generally attainable with proper care and workmanship, where the nature of the excavated material is borne in mind. Care shall also be taken not to undercut any slopes which would cause sections to have a steeper slope than specified. All loose material shall be removed.
c) Cut and Fill slopes requiring lining: The deviation of the final slope profile from a line joining any two points on the slope, 30 m apart, shall not exceed 150 mm.

15.8.2.3 Compaction Density

At least 4 relative density determinations per density test shall be taken for Fill and Selected Fill layers. After outliers have been examined and replaced, density test results shall conform to the minimum values given in Table 15/4.

15.9 TESTING

15.9.1 Testing by the Contractor

15.9.1.1 Testing for Pipelines

(a) Testing

The Contractor shall carry out sufficient tests to satisfy himself as to the consistency of materials placed in the trench. The testing for consistency of soil materials shall at least include grading analysis and Atterberg Limits from routine sampling daily at each compaction production front for bedding, bedding cradle and selected fill. Any observed change in material colour or particle size shall trigger consistency testing.

In addition the Contractor shall carry out routine density control tests to ensure that the specified densities are being attained and shall make out-of-roundness measurements of all pipes laid prior to backfilling and on completion of backfilling. Records of the test results and measurements and the working sheets used shall be kept in a systematic manner and shall be submitted to the Engineer within 24 hours of being completed or available.

All Site testing carried out by the Contractor shall be performed in a suitably equipped and staffed laboratory by competent and sufficiently experienced laboratory staff. Off-site testing shall be carried out by a recognized testing institution, a laboratory or a firm approved by the Engineer.

(b) Density Testing

The Contractor shall carry out sufficient density tests (each comprising at least 4 density determinations) to ensure that the specified densities are being attained for each component of the trench backfill. The minimum testing frequency and requirements are given below:

Main Backfill:	Frequency	- 4 density tests per 200 m^3
		- At least 3 tests per layer
	Minimum density	- See Clause 15.7
Bedding Material:	Frequency	- 4 density tests per 100 m^3
		- At least 3 tests per layer
	Minimum density	- See Clause 15.7

(c) Out-of-Roundness

When the pipe is laid in position in the trench and prior to the commencement of any backfilling layer (Bedding Cradle, Selected Fill Blanket and Main Backfill), the Contractor shall measure with a suitable measuring device and record the horizontal and vertical internal pipe dimension at six equally spaced intervals along each pipe length recording the number of the pipe and the chainage at which it was installed. When the Main Backfill has been completed to ground level, the Contractor shall re-measure the horizontal and vertical internal pipe dimension following the same procedure. Any out-of-roundness over and above the maximum allowable shall be corrected.

Measurements shall be taken to an accuracy of 1.0 mm and the Contractor shall provide suitable equipment and adequately trained labour to carry out the measurements. The recorded information and measurements shall be submitted to the Engineer within 24 hours of the time that any measurement was taken.

The out-of-roundness shall be defined as the difference between the vertical internal pipe dimension and the internal diameter of the pipe with zero out of roundness (ID), divided by the ID times 100 to obtain a %. The “maximum allowable out-of-roundness” shall be plus or minus 2% for pipes with cement mortar lining and plus or minus 3% for pipes with any other type of lining and coating, unless the 2% and 3% values are reduced by the designer.

If the out-of-roundness after the placing of the Main Backfill exceeds the “maximum allowable out-of-roundness”, the Contractor shall remove the full depth of the Main Backfill, the Selected Fill Blanket and the Bedding Cradle over the length of pipe that shows excessive out of roundness. After the removal of each of the three layers, the Contractor shall measure the horizontal and vertical internal pipe dimension as specified above. The Contractor shall then test the Bedding for material quality (soil type) and compaction. If the out-of-roundness and bedding comply with the specifications and after acceptance by the Engineer, the backfilling could proceed. Other methods of repair proposed by the Contractor will be subject to the Engineer’s acceptance.

The Contractor shall prepare a Method Statement prior to commencing with the rectification work.

15.9.1.2 Testing for General Earthworks, Embankments and Terracing

(a) Testing

The Contractor shall carry out sufficient tests to satisfy himself as to the consistency of materials. The Contractor shall carry out routine density control tests to ensure that the specified densities are attained. Tests for the maximum dry density and optimum moisture content, Atterberg Limits, CBR and CBR swell and particle size analysis shall also be carried out. Records of the test results and measurements and the working sheets used shall be kept in a systematic manner and shall be submitted to the Engineer within 24 hours of being completed or available.

All Site testing carried out by the Contractor shall be performed in a suitable suitably equipped and staffed laboratory by competent and sufficiently experienced laboratory staff. Off-site testing shall be carried out by a recognized testing institution, a laboratory or a firm approved by the Engineer.

(b) Density Testing

The Contractor shall carry out sufficient density tests (each comprising at least 4 density determinations) as approved by the Engineer to ensure that the specified densities are being attained.

The minimum testing frequency and requirements are given below:

Fill:	Frequency	- 4 density tests per 100 m^3
		- At least 3 tests per layer
	Minimum density	- See Clause 15.7
Selected Fill:	Frequency	- 4 density tests per 100 m^3
		- At least 3 tests per layer
	Minimum density	- See Clause 15.7
Structure Backfill:	Frequency	- 4 density tests per 100 m^3
		- At least 3 tests per layer
	Minimum density	- See Clause 15.7

15.9.2 Testing by the Engineer

In addition to the control testing carried out by the Contractor, the Engineer may order additional density tests to be carried out by the Contractor.

If the density is found to be below the specified value, the Engineer may order the re-compaction of the backfill at the Contractor’s expense. The Contractor shall bear the cost of all monitoring and acceptance of density tests.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 16

EMBANKMENT CONSTRUCTION

TCTA MODULAR STANDARDS
SECTION 16
EMBANKMENT CONSTRUCTION

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SECTION 16
EMBANKMENT CONSTRUCTION

16.1 SCOPE

This Section covers the requirements for the construction of small earth dams/embankments of height up to 15 m as defined by the International Commission on Large Dams (ICOLD). It covers excavation, subsoil drainage system, the selection, placing, and compacting of materials in the various zones of the embankment and the preparation of the surface for the lining.

This Section does not cover the following:

- Opening up, operating and reinstatement of borrow pits and quarries;
- Drilling and grouting;
- Dam lining;
- Concrete works as part of dam / embankment; and
- Landscaping and vegetating of the embankments.

16.2 SUPPORTING SECTIONS

Section 16 shall be read in conjunction with the following Sections:

- Section 1 – General;
- Section 5 – Survey and setting out;
- Section 7 – Clearing Site;
- Section 8 – Dealing with Water;
- Section 9 – Bulk Surface Excavations and Trenching;
- Section 12 – Blasting;
- Section 14 – Spoil, Borrow and Excavated Materials;
- Section 17 – Reservoir membranes and Linings;
- Section 18 - Drilling and Grouting
- Section 20 – Concrete works (Structural);
- Section 47 – Landscaping and Rehabilitation; and
- Section 48 – Tests on Completion.

The reference to the sections above does not preclude the use of any other relevant Section of the Modular Standards.

16.3 DEFINITIONS, ABBREVIATIONS AND REFERENCES

16.3.1 Definitions

For the purpose of this Section, the definitions and abbreviations given in the Sections listed in Clause 16.2 plus the following shall apply:

a) **"Dam basin"** the part of the catchment area that is upstream of a dam wall and that lies below the full supply level of the dam.

b) **"Dispersive soil"** a material that consists of clayey particles of colloidal size in a state in which they can easily go into suspension in water.

c) **"Drainage zone"** A zone that acts mainly to conduct water safely through the dam to the downstream area. This function is also attributed to filter and transition zones.

d) **"Filter material"**

   i) A material that has a grain size distribution such that the voids between grains are smaller than the finest grains of adjoining material on one hand and with a grain size that is larger than the interstices of adjoining material on the other hand; or

   ii) A material such as a fine aggregate, a sandy material, or a woven or a non-woven fabric (geotextile) having pore sizes that are fine enough to prevent the migration of soil particles from a soil mass adjoining it.

e) **"Optimum moisture content (OMC)"** The moisture content at which the maximum dry density occurs in the test for Proctor density.

f) **"Proctor density"** The maximum dry density determined at OMC in accordance with the method given in ASTM D 698.

g) **"Riprap"** a surface layer of rockfill material placed to a specified controlled thickness.

h) **"Transition zone / Riprap bedding"** Layers or zones that are located between the earthfill materials and the riprap.

i) **"Approved laboratory"** A material laboratory suitably equipped and staffed for purposes of earthworks and aggregate testing and approved by the Engineer.

j) **"Relative Density"** The state of compactness of a soil with respect to the loosest and densest states at which it can be placed. This is applicable to non-cohesive materials which do not have well-defined moisture / density curves. (ASTM D4254).

k) **"Slope protection"** The outer zone of an embankment which can either consist of topsoil and grass or transition layers and riprap.

l) **"Zone (of an embankment)"** A section of an embankment that is wholly constructed with material that conforms to a particular set of physical characteristics that are different from those of the material of an adjoining section.

m) **"Deviation"** The difference between the actual (i.e. measured) size or position and the specified size or position.

n) **"Permissible deviation"** The specified limits of deviation.

16.3.2 Abbreviations

ICOLD: International Commission on Large Dams
OMC: Optimum Moisture Content
PD: Permissible Deviation

16.3.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014, Construction Regulation 13 - Excavations, Explosive Regulation when blasting, Construction Regulation 11 - Structures, Construction Regulation 12 - Temporary works and Construction Regulation 26 - Water environments**.**

16.4 MATERIALS

16.4.1 General

The water used for washing or compacting embankment materials shall be free from silt or other suspensions that might detrimentally affect the material properties.

The material being placed in any layer of any particular zone shall be homogeneous, uniformly graded and at all times conform to the specified grading and other properties. The Contractor's methods of transporting, placing, spreading, mixing and compacting the materials shall not cause excessive degradation or segregation.

The quality of the materials placed in an embankment and the methods of procuring and processing the materials shall at all times be subject to the approval of the designer and review of the Engineer.

16.4.2 Classification for Excavation Purposes (not applicable to lump sum payments)

16.4.2.1 Method of Classifying

The Contractor may use any method to excavate any class of material, but the chosen method of excavation shall not necessarily determine the classification of the excavation. The Engineer will decide on the classification of the materials. The classification will be based on inspection of the material to be excavated and on the criteria given in Clause 16.4.2.2.

In the event of disagreement between the Contractor and the Engineer, it shall be the responsibility of the Contractor, if instructed by the Engineer and subject to the terms of Clause 16.5.1, to make available such mechanical equipment as specified in Section 9 - Bulk Surface Excavations and Trenching, in order to demonstrate the classification of the material. The decision of the Engineer on the classification shall then be final and binding.

16.4.2.2 Classes of Excavation

The excavation of material will be classified as follows for purposes of measurement and payment:

(a) Soft Excavation

See Section 9 – Bulk Surface Excavations and Trenching.

(b) Hard Rock Excavation

See Section 9 – Bulk Surface Excavations and Trenching.

(c) Boulder Excavation Class A

See Section 9 – Bulk Surface Excavations and Trenching.

(d) Boulder Excavation Class B

See Section 9 – Bulk Surface Excavations and Trenching.

16.4.3 Classification for Placing Purposes

Refer to Annexure 16/1 for definition of Zones.

16.4.3.1 Zone 1: Selected Earthfill Material (Impervious)

Selected earthfill material used as earthfill:

a) Shall be free of stumps, trees, rubbish, organic matter, and other deleterious materials;
b) Shall conform to the specified size limits and grading boundaries and physical properties for the various embankment zones;
c) Shall be compactable to the density specified; and
d) May contain isolated individual stones and boulders of maximum dimension up to two-thirds of the compacted layer thickness, provided that the volume of the stones and boulders does not exceed 15% of the volume of the layer.

16.4.3.2 Zone 2: Unselected Earthfill Materials

Unselected eathfill material shall consist of miscellaneous mixtures of clay, silt, sand, gravel, cobbles, and rock fragments to 200 mm maximum dimension. Boulders and rock fragments larger than 200 mm maximum dimension shall be removed from otherwise acceptable unselected earthfill material, either at the site of excavation or after the material has been placed in the embankment, but before the material is compacted. Such oversize boulders and rock fragments may either be used as rockfill material or spoiled.

16.4.3.3 Zone 3: Rockfill Material for Embankment

Rockfill used in the embankment and as riprap shall:

a) Be hard, dense, durable material that is free from weathering; and
b) Conform in mass and size limits to the values given below.

The rockfill shall consist of rock fragments reasonably well graded between 200 and 1000 mm (varies for different purposes and material sizes) in maximum dimensions of the individual fragments. The rockfill may contain materials less than 200 mm size provided that the quantities do not exceed the amount required to fill the voids in the larger rock. Individual rock fragments larger than 1000 mm may be embedded in the rockfill within 2 m of the downstream slope.

16.4.3.4 Zone 4: Filter, Drain and Transition Zone Materials

Sands and gravels required for use in drains and filters shall:
a) Be clean and contain no organic material;
b) Contain no soft friable particles;
c) Consist of hard, durable, and well-shaped particles; and
d) Have a grading between the specified limits.

Where necessary aggregates shall be washed to ensure that the grading and other quality requirements are complied with.

The coarse aggregates shall meet the minimum requirements of stone for concrete as specified in SANS 1083 and shall not have any property which, in the opinion of the designer, could adversely affect the functioning of the filter, drain or transition zone. Should the Contractor be unable or elect not to produce the materials as crusher run, the coarse aggregate shall be separated and separately stockpiled in applicable sizes of stone. The coarse aggregate shall meet the prescribed requirements of the 10% FACT value for a concrete not subject to surface abrasion. The coarse aggregate shall be tested for the following properties:

- Shape (as indicated by voids content). Testing shall be conducted in accordance with SANS 5846 and the voids content shall not exceed 48%;

- Soundness. When tested in accordance with ASTM C88 (sodium and magnesium sulphate method), the coarse aggregate shall not indicate a loss in mass of more than 8%;
- Abrasion resistance. The abrasion resistance, when tested in accordance with SANS 5846, shall not exceed 48; and
- Flakiness index. The testing shall be carried out in accordance with SANS 5847 and the flakiness index shall not exceed 35%.

In addition, all the non-soluble deleterious materials, including materials of low density, in each size fraction shall not exceed 3% by mass.

The fine aggregates used in filters shall meet the requirements of sand for concrete in SANS 1083 unless otherwise approved by the designer and shall have no property which, in the opinion of the designer, could adversely affect the functioning of the filters.

The fine aggregate may be of either class specified in Table 1 of SANS 1083 or may be a blend of both classes. The specified filter grading shall be achieved by the blending of at most two types of sand. Different types and classes of sand shall be separately stockpiled.

The fine aggregate shall be tested for the following properties:

- Content of material of low density;
- Soundness. When tested in accordance with SANS 5847 (sodium sulphate method), the fine aggregate shall not indicate a loss of more than 8%; and
- Other impurities.

In addition, all the non-soluble deleterious materials, including materials of low density, in any size fraction shall not exceed 2% by mass.

In general and unless otherwise approved by the designer, these materials shall comply with the requirements for concrete aggregate in SANS 1083 with the following modifications:

- The dry 10% FACT value shall not be less than 110kN; and
- The wet 10% FACT value shall be at least 75% of the determined dry value.

The Contractor shall construct storage facilities that:

- Provide adequate capacity to ensure no interruption to the construction;
- Provide separate storage areas for different types and sizes of material;
- Ensure there is no intermixing nor contamination by deleterious matter;
- Ensure there is no segregation; and
- By restricting the height of the stockpiles, ensure that no breakdown of particles takes place.

16.4.3.5 Zone 5: Riprap

All stone for riprap shall be of rock of a petrographic type approved by the designer and shall be quarry or excavation run processed only to remove excess fines or to remove or degrade oversize particles and shall meet the following requirements:

a) Be hard, dense, durable quarried rock that is free from weathering, cracks, seams and other defects that will cause rapid or excessive deterioration or degradation during service;
b) Conform to the specified grading (see Clause 16.8.10) and the requirements stated in Clause 16.4.1;
c) Contain no more than 5% by mass in total of impurities (or undesirable material) such as individual pieces of riprap which do not meet the quality requirements as specified and which can be visually differentiated from satisfactory pieces, plus dirt, sand, clay, rock fines and material of low density;
d) The specific gravity of the individual particles shall be greater than 2.60;
e) The dry 10% FACT value determined in accordance with SANS 5842 shall not be less than 110 kN;
f) The wet 10% FACT value determined in accordance with SANS 5842 shall not be less than 75% of the determined dry value; and
g) The loss after 5 cycles measured by the sodium sulphate soundness test (see Clause 16.8.9) shall not be greater than 8%.

16.4.3.6 Zone 6: Pervious Backfill

The materials to be used for pervious backfill shall be selected pervious mixtures of sand, gravel and cobbles, reasonably well graded to a maximum size of 150 mm, except that occasional larger fragments may be used if well distributed in the backfill. The pervious backfill shall not contain more than 5 percent, by mass, of material passing a 75 micron sieve.

16.4.3.7 Zone 7: Rock Backfill

The material used for rock backfill shall be selected angular rock fragments, reasonably well graded, from 75 mm to 200 mm in minimum and maximum dimensions; and shall be obtained from the same type of rock source, and be of the same quality, as required for riprap in Clause 16.4.3.5; selected from rock materials from required excavations, or obtained from an identified borrow area. The rock backfill shall contain no more than 5 percent, by mass, of material passing a 75 micron sieve. Materials less than 75 mm in maximum size may be used in an amount only sufficient to fill the voids in the coarser material.

16.4.3.8 Zone 8: Gravel for Downstream Face Protection

Gravel used for downstream face protection shall comply with the following requirements:

- Gravel shall comprise hard, clean rock particles;
- Gravel shall have a maximum particle size of 75 mm, shall be continuously graded and have a maximum of 5% passing the 75 micron sieve;
- Gravel shall be clean and conform to the specified grading. Where necessary aggregates shall be washed with to ensure that the grading and other quality requirements are compiled with;
- Gravel shall meet the minimum requirements of stone for concrete as specified in SANS 1083 and shall not have any property which, in the opinion of the designer, could adversely affect the functioning of the filter, drain or transition layer; and
- Gravel shall meet the prescribed requirements of the 10% FACT value for a concrete not subject to surface abrasion.

16.4.3.9 Zone 9: Gravel Capping

Gravel capping material shall have:

a) A minimum CBR of 45% at 95% of modified AASHTO maximum density;
b) A maximum CBR swell of 0,5% at 100% of modified AASHTO maximum density;
c) A plasticity index of not less than 6 and not more than 12;
d) A maximum particle size of 50 mm; and
e) Between 30% and 40% of the material shall be retained on a 13.2 mm sieve.

16.4.3.10 Zone 10: Transition layer / Riprap Bedding

The materials for the transition layer / riprap bedding shall comprise a pervious mixture of sand, gravel and cobbles reasonably well graded from 5 mm to 150 mm in maximum dimensions, but may contain materials smaller than 5 mm in quantities not to exceed the amount required to fill the voids between the materials larger than 5 mm, provided that the material shall contain no more than 5 percent, by weight, of material passing a 75 micron sieve.

Should cobbles and boulders having dimensions of more than 150 mm be found in otherwise acceptable materials, they shall be removed by the Contractor either at the Site of excavation or after being placed. Such oversize cobbles and boulders may be placed in Zone 5 or 6 or spoiled, as directed by the designer.

16.5 EQUIPMENT

16.5.1 Excavation Equipment

Although particular items of equipment are specified in Clause 9.2, for the classifying of excavations, the Contractor is not obliged to provide or use those particular items of equipment for carrying out the work.

16.5.2 Crushing and Screening Equipment

If required, the Contractor shall supply and erect, in a position approved by the Engineer**,** a suitable crushing facility to produce the material required for the filters, drains and transition layers.

16.5.3 Batching Plant for Filters, Drains and Transition Zones

Where aggregates are to be combined to produce material conforming to the specified grading, the Contractor shall provide a batching system which is efficient and accurate. Materials that do not bulk when moist may be measured by mass or volume. Fine aggregate fractions that bulk when moist shall be measured by mass. The measuring equipment shall ensure that the batched amount of each constituent is within 5% of the required quantity.

The Contractor shall carry out all necessary calibrations and regular checks to the approval of the designer to ensure that this degree of accuracy is maintained throughout the Contract. Regular checks shall be carried out before commencing every new shift and, or at least at the start of each day on which materials for filters, drains and transition layers are being batched. The layout of the facility and its mode of operation shall ensure that the materials are kept uncontaminated throughout the batching process and that changes in moisture content do not occur between measurements made to adjust for moisture content when using mass batching. In addition, adequate safeguards shall be provided that ensure ingredients are not omitted or duplicated. The measuring system installed shall be capable of ready adjustment of the proportions whenever this is found to be necessary.

16.5.4 Mixing or Blending Equipment for Filters, Drains and Transition Zones

The equipment shall ensure a uniform distribution of the ingredients and that the mixed or blended batch is not segregated on completion. The Contractor shall consult with the designer on the mixing or blending time to be used for the type of equipment employed and this shall not be varied without prior approval of the designer.

16.5.5 Loading and Transport Equipment

The equipment used to load and transport material from the quarries, borrow pits and batching facility shall be of adequate capacity to ensure that the grading of each load conforms as nearly as is practicable to the average grading of the material in the particular zone being placed. The loading equipment used in quarries shall be operated in such a way that will ensure a minimum amount of

degradation in the quarries subject to meeting the specified grading requirements for the particular zone being loaded Tracked vehicles shall not be used on the embankment if these are found to cause a degradation of any of the placed materials. The equipment used by the Contractor shall at all times be designed and operated to keep wastage of the materials to a minimum.

16.5.6 Spreading Equipment

The equipment used on the embankments for spreading material such as bulldozers, graders and ploughs shall be of sufficient capacity to ensure that adequate inter-mixing of the various loads of dumped material is obtained without segregation, and without bridging of the larger particles with consequent large voids in the spread material.

Adequate spreader boxes and formwork where necessary shall be provided on Site for placing and spreading filter or drain materials without segregation or contamination.

Whenever, in the opinion of the Engineer, the Contractor's placing, spreading and mixing techniques on the embankments are such as to cause degradation or segregation of the material the Contractor shall immediately take corrective measures.

16.5.7 Compaction Equipment

The selection of compaction equipment to be used for foundation preparation, fill, filter and drain construction shall be based on the construction of the trial embankment. Impact rollers will not be allowed.

Compaction equipment used against a concrete (or masonry) structure shall be capable of compacting material against a near vertical face, i.e. the edge of the roller must reach the concrete face.

16.6 CONSTRUCTION

16.6.1 General

No core materials shall be placed or foundation preparations performed in an area where the designer has not given his specific approval of that particular portion of foundation.

The embankment shall be constructed to the specified lines, levels and slopes, with adequate allowance for settlement during construction as required in terms of Clause 16.6.4.5. The Contractor shall include in his embankment construction method statement, the manner in which this will be achieved.

Surface or subsurface water, which is encountered during the progress of the work, shall be dealt with by the Contractor in terms of Section 8 – Dealing with Water.

The Contractor shall safeguard excavations to comply to the relevant acts, regulations, specifications and other requirements. Without relieving the Contractor in any way of his responsibilities, the Engineer or designer may order additional lateral support for, or the sloping or reduction of the slope of, the sides of any excavation.

During the progress of excavation, the Contractor shall report to the designer the presence of bedding planes inclined towards the excavation, seepage water, and any other feature that may affect the stability of the excavation, as soon as the presence of such feature(s) is known.

All timbering and sheeting shall be removed from the excavation before the completion of the work, unless the permission of the designer allowing any portion to remain is obtained.

Should blasting be necessary, the Contractor shall take every precaution to protect the Works and persons, animals, and property in the vicinity of the Site. The Contractor will be held responsible for any injury or damage caused by any blasting operations and shall make good such damage as a matter of urgency.

The blasting process shall be executed in terms of the requirements of Section 12 - Blasting. When blasting to specified profiles, the Contractor shall arrange the holes and charges to ensure that exposed surfaces are as sound as the nature of the material permits. The Contractor shall make good additional excavation resulting from blasting or the shattering of rock.

16.6.2 Trial Embankment Construction and Tests

The Engineer may order the construction of a trial embankment to test the properties and compaction characteristics of each type of earthfill material.

The trial embankment shall be constructed on a cleared section of ground after stripping the surface of topsoil and clearing unacceptable material.

The trail embankment shall be constructed for each type of material with the aim of determining:

a) The optimum and/or maximum thickness of the layers to be placed;
b) The number of passes required with the compaction equipment to obtain the specified percentage of maximum Proctor Density for a particular thickness of the layer;
c) The type and mass of the compacting equipment to be used;
d) The behaviour of the material when placed and compacted at its specified moisture content range and the effect of over-compaction on the material; and
e) The correlation obtained between density and moisture content by means of the wax density, Sand Displacement Method, Core Cutter density methods and the Hidrodensimeter.

16.6.3 Methods and Procedures

16.6.3.1 Clearing and Stripping of Site

The Contractor shall clear the foundation area of the embankment. This shall consist of:

i) The removal and disposal of all trees, bushes, and other vegetation (complete with roots), rubbish, fences, structures and all other material that may interfere with the construction of the embankment, spillway, and ancillary works; and

ii) The removal and stockpiling of riprap, rocks and boulders of size up to 0,15 m^3 that are lying on the surface including those that are exposed during the clearing operations; and

If there is suitable topsoil within the limits of the area to be cleared, the Contractor shall remove and conserve the topsoil together with any grass or other acceptable vegetation. If it is not used immediately or if it is not stockpiled in windrows clear of the working areas, the topsoil shall be conserved for later use in the manner specified in Section 7 for finishing of the embankment or elsewhere.

The Contractor shall remove trees and bush from the area of submergence e.g. weir or dam basins.

16.6.3.2 Excavation

(a) Foundation

After the foundation area has been stripped, excavation shall be carried out to the specified depths or greater depths as may be by the designer to ensure a satisfactory foundation.

All excavated surfaces shall be trimmed to ensure that there is no projection into the excavation profile that is greater than the tolerance specified in Clause 16.7.2., as relevant.

Any extraordinary feature such as heritage resources (fossils, artifacts, etc.), human remains, unexpected ground water, or an unexpected geological feature shall be reported to the Engineer before it is removed or covered.

(b) Preparation of Exposed Surfaces

(i) Rock Surfaces

Except as specified otherwise in Clause 16.6.3.3, all rock surfaces exposed in the cut-off trench or foundation shall be prepared as specified in Clause 16.6.3.2 (b)(i).

Rock surfaces exposed in the cut-off trench or embankment and spillway foundation areas shall be excavated to sound rock and washed clean using air and water jets.

Abrupt changes in section, for example benches on the abutment slopes, shall be avoided. Surfaces against which material is to be placed shall be excavated to slopes not steeper than 1:1.

No surface treatment, including joint and crack grouting, shall commence until all the required blasting within 100 m of the area to be treated has been completed.

All loose and partly detached blocks of rock shall be removed. All knobs, projections, and overhangs of rock shall be removed by barring and wedging or light blasting. In order not to open up joints or otherwise disturb the rock surface, the amount of blasting shall be kept to a practicable minimum. No blasting shall be done on surfaces that have been grouted or slush-grouted.

Joints and cracks that are exposed in the excavation shall be cleaned to a depth of not less than three times their width at the surface. Such joints and cracks shall then be filled with grout. Where possible, a pipe shall be set at the bottom of a joint or crack and grout shall be pumped in until the joint or crack is completely filled. Grout shall then be broomed and brushed across the top of the joint or crack to ensure that the contact with the core or other zone material will be tight and non-erodible. Except in the case of small cracks, the brushing of slush grout to fill a crack is not acceptable.

Grout used for the purpose of filling cracks shall be highly plastic and buttery. The maximum size of aggregate in grout used for filling a crack shall not exceed one-third of the width of the crack.

Depressed areas, potholes, and similar irregularities shall be filled with a plastic mix of 20 MPa/40 mm concrete vibrated into place. Small ribs and similar irregularities shall be filleted to produce a slope not steeper than 1:1.

The final rock surface shall have smooth contours against which soil can be compacted by heavy equipment.

(ii) Soil Surfaces

Except as specified otherwise in Clause 16.6.3.3, all soil foundation surfaces shall be prepared as specified in this section (Clause 16.6.3.2 (b)(ii)).

Before each soil foundation is inspected by the designer and Engineer, the Contractor shall ensure that all loose material is removed from the foundation. After the foundation has been inspected by both, the soil shall be ploughed to a depth of 150 mm, wetted or dried, as applicable, and then compacted to at least 95% of

the Proctor density (see Clause 16.7.2.2) except that where the presence of dispersive soil has been proved by the designer, the density shall be at least 98% of the Proctor density. After the soil has been compacted, the surface shall be scarified to a depth of 25 mm to ensure bonding with the fill material and, immediately after that, the embankment fill shall be placed directly on the prepared surface.

(c) Borrow Pits

The Contractor shall first clear the surface of the sites in accordance with the applicable requirements of Section 14 - Spoil, Borrow and Excavated Materials. Topsoil and overburden shall be stripped and stockpiled separately. The Contractor shall so maintain borrow pits that they do not become a danger to persons and livestock.

The Contractor shall plan and operate borrow pits to obtain maximum use of the materials. Haulage and access roads shall be kept to a minimum and the Contractor shall inform the Engineer of any proposed routes for haulage and access roads to and from the borrow areas. The management of borrow pits shall be done according to Section 14 - Spoil, Borrow and Excavated Materials.

(d) Disposal

The Contractor shall not spoil, stockpile, or waste any material without approval by the Engineer. In addition to complying with the requirements of Clause 16.6.4.2 (c) for the disposal of unused material from borrow pits, he shall dispose of surplus and unsuitable material in designated spoil areas.

16.6.3.3 Preparations of Receiving Surfaces

The final receiving surfaces which are to be accepted by the designer and Engineer shall be treated and prepared as follows:

(a) Zone 1: Selected Earthfill Materials (Impervious)

After excavation (see Clause 16.6.3.2), all loose blocks shall be removed from the contact area. All knobs and overhangs shall be removed using barring and wedging. If light blasting is required, the prior approval of the designer will be required.

In areas of rock surface foundations, all fissures such as crevices, seams or joints shall be raked out to remove all unsuitable material for as deep as possible (but not less than 3 times the width at its widest point) and then cleaned with air / water jets. Fissures with an average width of less than 25 mm shall be filled with cement grout having a water: cement ratio of not more than 0.67. Fissures between 25 mm and 75 mm wide shall be filled with a cement mortar rodded into position with steel bars. The mortar shall comprise sand and cement in the same proportions as used for a grade Class 25 concrete. Wider features shall be filled with a Class 25/19 concrete. Grout shall be broomed and

brushed across the top of all filled crevices and seams to ensure that the contact with the core material will be tight and non-erodible. Small cracks may be treated by brushing of slush grout having a water:cement ratio of not more than 0.67.

Depressed areas and other irregularities in the rock surface shall be filled with a Class 25/19 or Class 25/38 concrete vibrated into place. Small ribs and similar irregularities shall be filled to produce a slope not steeper than 1(V):2(H). The final rock surface after treatment shall have smooth contours against which the core material can be compacted to specification by heavy equipment.

In areas of cohesive and non-cohesive core foundation materials, the foundation preparation as described in (a) above for the embankment shells shall apply mutatis mutandis (with respective differences taken into consideration).

(b) Zone 1: Selected Earthfill Materials (Semi-Pervious)

In areas of cohesive foundation materials, the in-situ material shall be scarified to a depth of 150 mm and conditioned to within minus 1% and plus 2% of the OMC and then compacted to a dry density of nowhere less than 95% of the Proctor density.

In areas of non-cohesive foundation materials the in-situ material shall be compacted with vibratory rollers conforming to the specified requirements. The number of passes for the specified rollers will be determined on Site by the designer and will vary in accordance with the thickness of the material to be compacted and until a relative density of at least 70% is attained.

The Contractor shall water the foundation materials, both cohesive and non-cohesive, in the amount and in accordance with the requirements specified by the designer. Such watering shall be carried out immediately prior to compaction or during late afternoon and/or evening preceding early morning compaction on the following day, whichever the designer decides, and in a manner to reduce moisture losses to a minimum. Watering of the foundation shall be carried out uniformly over the whole area to be compacted. If the Contractor delays compaction operations after water has been applied to the foundation or wastes water in this operation, more water to the foundation shall be added until specified requirements are met before compaction is commenced.

This work shall be performed over short lengths of the foundation to prevent subsequent loosening up and any areas that become loose due to any cause whatsoever shall be re-compacted by the Contractor. Consecutive passes of vibratory and impact rollers shall be adjacent to each other and shall overlap only sufficiently to ensure full coverage of the surface by each pass. A “pass” for a double drum impact roller is defined as two passes of the roller such that one drum of the roller during its second passage travels in the inter-drum space created by the first passage of the impact roller. An efficient method of lane marking shall be used to ensure that accurate tracking of the roller drums is maintained.

(c) Zone 2: Unselected Fill Materials

The foundation for Zone 2 materials shall be prepared by levelling, moistening, and compacting so that the surface materials will be as compact as specified for subsequent layers of the zone.

In areas of cohesive foundation materials, the in-situ material shall be ploughed to a depth of 250 mm and conditioned to the specified OMC and then compacted to a dry density of nowhere less than 98% of the Proctor density. The surface shall then be scarified to a depth of 25 to 40 mm with cut marks not further than 150 mm apart.

In areas of non-cohesive foundation materials the in-situ material shall be compacted with suitable vibratory rollers conforming to the specified requirements. The number of passes for the specified rollers will be determined on Site by the designer and will vary in accordance with the thickness of the material to be compacted and until a relative density of at least 70% is attained.

This work shall be performed in such a way as to prevent subsequent loosening up of the compacted foundation and any areas that become loose due to any cause whatsoever shall be re-worked, moisture conditioned and re-compacted by the Contractor.

An efficient method of lane marking shall be used to ensure that accurate tracking of the roller drums is maintained.

(d) Zone 3: Rockfill Material for Embankment

Fine and other materials unsuitable for the support of rockfill shall be removed. No material shall be placed until the foundation has been dewatered, stripped and suitably prepared. All cavities, depressions and irregularities shall be cleaned and filled with rockfill materials compacted as specified, or slush grouted and filled with dental concrete.

Areas of weathered rock shall be scarified to a depth of 150 mm and conditioned to within minus 1% and plus 2% of the OMC and then compacted to a dry density of nowhere less than 95% of the Proctor density.

(e) Zone 4: Filter, Drain and Transition Zone Materials

The provisions of Clause 16.6.3.3 (d) shall apply.

(f) Zone 5: Riprap

The embankment receiving surface for Riprap shall be well compacted and free of loose material.

(g) Zones 6 to 9

The embankment receiving surface shall be well compacted and free of loose material. Placing of core material shall commence immediately after the surface has been prepared as specified above, to avoid deterioration of the material or prepared surface. If the Contractor fails to meet this requirement, any additional preparatory work required shall be carried out to the satisfaction of the designer.

(h) Zone 10: Transition layer / Riprap Bedding

The embankment receiving surface for riprap bedding shall be well compacted and free of loose material.

16.6.3.4 Batching, Mixing, Blending and Loading of Materials

Where deemed necessary by the designer, all constituents of the filters, drains and transition layers shall be batched in the proportions required to comply with the respective specific grading requirements.

The mixing or blending of materials for filters, drains and transition layers shall be conducted by an experienced operator. The sequence of charging the mixing or blending equipment shall be approved by the designer prior to commencing the earthworks operations and this sequence shall be maintained unless otherwise approved by the designer. The quantity of the mixed material per batch shall not exceed the rated capacity of the mixing and blending equipment. No ingredients shall be added while the mixer is stationary.

The discharge from the mixing or blending equipment shall be arranged so that there is no segregation of the materials in the mix. Mixers shall be completely emptied before being recharged.

Adequate precautions shall be taken to ensure that the materials loaded into the vehicles for placement in the embankments conform to the specified requirements and have been conditioned accordingly. The Contractor shall ensure that during the loading operation for filter and riprap material excess fines are not picked up from the quarry or stockpile floors and if special rock-loading buckets are used, the loading face shall be cleared continuously to remove the concentration of fines from the floor. This material shall either be spoiled or stockpiled for later use in another embankment zone requiring finer material. In the event of the Contractor using a grizzly to remove excess fines or oversize material, as the case may be, the oversize or undersize fraction shall be disposed of or used in accordance with the instructions of the designer, and the Contractor shall take all the necessary precautions to prevent uncontrolled mixing of materials.

The Contractor shall selectively load all suitable materials from the dam excavations, borrow pits and quarry to prevent contamination with unsuitable overburden and unsuitable material as defined in the relevant specifications. No oversize material shall be brought onto the embankments.

16.6.3.5 Material Processing

Where required, material shall be processed by screening, heavy grid rolling or bentonite processing.

Before being placed, the material shall be passed through a screening equipment, with screens of the required or specified sizes, to remove the oversize fraction and unsuitable or excess fines. The screened-out material shall be removed to spoil sites and disposed of.

Heavy grid rolling shall be carried out with a grid roller of mass at least 13t and travelling at a speed of at least 12 km/h. Every portion of the layer shall be covered by at least 4 passes of the roller. The material shall be windrowed to one side of the layer, shall be checked for oversize material, and the oversize material shall be removed. The material shall then be re-spread and again grid rolled as before. The process shall be repeated until all oversize material is broken down or removed.

Bentonite shall be evenly spread over the layer to be processed. Immediately after the bentonite has been applied, it shall be mixed with the layer material, for the full depth of treatment. Mixing shall be continued for as long and repeated as often as may be required to ensure a thorough, uniform and intimate mix of the material to be processed and the bentonite.

The resulting mixture shall be homogeneous. The material shall then be wetted, water mixed in and the layer compacted.

The specified allowance for settlement shall be taken into account during construction.

16.6.3.6 Placing and Spreading

(a) Embankment General Requirements

The material of the embankment shall be placed in layers of thickness, before compaction, not exceeding 250 mm unless specified otherwise by the designer. The material shall be spread over the area of the embankment and sloped sufficiently to allow for the run-off of rainwater. Where the dam is constructed across a river, the construction level of the embankment always shall be on the same horizontal level throughout to avoid concentration of floods.

Each layer shall be compacted, mainly by means of heavy compaction equipment, to at least the Proctor density specified for the particular zone or, where no such density is specified, to at least 95% of Proctor density, subject to the applicable tolerance specified in Clause 16.7.

Should the material of the top layer of compacted material be too wet to allow the next layer to be placed, it shall be harrowed and allowed to dry out to the specified moisture content and re-compacted. Should the top layer of compacted material dry out and form shrinkage cracks, it shall be harrowed, rewetted, and re-compacted. The top surface of each layer shall be sufficiently rough

to ensure proper bonding with the succeeding layer. The Contractor may be required to scarify the surface if, in the opinion of the designer, the surface is too smooth to ensure proper bonding.

Fill material shall be placed 500 mm wider than the specified width to ensure proper compaction on the upstream and downstream slopes, and then cut back.

End slopes and side slopes of partial fill sections in the embankment shall not be steeper than 1 vertical to 4 horizontal.

The distribution and gradation of materials in any zone shall be such that the embankment will be free of lenses, pockets, streaks, and layers of material differing markedly in texture or gradation from the surrounding material.

(b) Rockfill, Riprap, Drains and Filters General Requirements

Stone for riprap shall be placed on the bedding layers to produce a reasonably well-graded mass of rock with the minimum practicable percentage of voids.

The larger stones shall be well distributed and the entire mass of stones in their final position shall be roughly graded to conform to the gradation specified. The finished riprap shall be free from unacceptable pockets of small stones and clusters of large stones. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the bedding material. The finished layer of riprap shall be a well-integrated, stable mass of rock.

No compaction will be required for riprap.

Non-vertical filter layers may be connected with short vertical sections (giving a stepped effect), to suit the Contractor's method of working.

Rockfill for use in the downstream toe and other portions of the embankment shall be dumped, with exposed surfaces finished off to present a neat appearance.

No compaction will be required for rockfill materials.

(c) Zone 1: Selected Earthfill Materials

Core and shell materials shall be placed in horizontal layers throughout, to a maximum permissible compacted thickness of 150 mm and 250 mm respectively or three times the maximum particle size, whichever is the larger. The maximum compacted thickness for core and shell materials in restricted areas, such as around the tongue walls and other structures shall be limited to 100 mm and 150 mm respectively. A slight cross fall from the chimney drain in both directions to the upstream and

downstream shall be maintained for draining stormwater and to prevent contamination of the chimney drain.

Whenever a layer or portion of a layer is placed to a compacted thickness of less than 50% of the maximum permissible thickness, it shall be bonded to the previous layer by scarifying the latter to a depth of 25 mm or such greater depth required to ensure a combined compacted thickness of 50% of the maximum permissible thickness, provided that no layer shall be placed to a thickness less than twice the maximum particle size.

The Contractor shall route haul vehicles and other Equipment over the entire area of the fill. There shall be no unnecessary concentration of routing vehicles tending to cause ruts, laminations or uneven compaction within the fill. Where such ruts, laminations or unevenness occurs, they shall be corrected to the satisfaction of the designer.

The widths of the various layers and the direction of placing shall follow a regular pattern. and the Contractor shall submit details of the layout of the layers to the designer for his approval before commencing with construction. In particular the Contractor shall stagger the longitudinal edges of the layers in a vertical section taken normal to these edges in order to avoid these contact areas from extending continuously over more than one layer. The contact between any two zones shall not be allowed to form a longitudinal edge of a layer. The layers and zones shall be placed that compaction can be conducted simultaneously along or across the zones to ensure complete integration of the two zones at the contact.

Construction shall at all times be commenced at the lowest point of the foundations. The embankments shall be constructed over the full width of each zone except for fill in the vicinity of filter zones. Under no circumstances, except where limited by the foundation profile shall any layer be less than 300 m in length.

The surface of any compacted layer, including the foundation layers shall be prevented from drying out and cracking by regularly watering the surface until it can be covered by the succeeding layer. Should the surface of any layer show signs of cracking the material shall be scarified to below the level of the deepest cracks, re-watered and re-compacted. Where the cracks extend to depths greater than the maximum permitted layer thickness, the Contractor shall rectify it as directed by the designer.

The top surface of each layer shall be sufficiently rough to ensure proper bonding with the overlying layer. If the surface is too smooth to ensure proper bonding the Contractor shall scarify the surface ensuring that the combined scarified thickness plus compacted thickness of the overlying layer does not exceed the maximum permitted layer thickness.

(d) Zone 2: Unselected Fill Materials

The material shall be placed in continuous and approximately horizontal layers, not more than 300 mm in thickness after being compacted as herein specified. The combined excavation and placing operations shall be such that the materials, when compacted in the miscellaneous fill, will be sufficiently blended to secure the best practicable degree of compaction and stability.

(e) Zone 3: Rockfill Material for Embankment

Rockfill material shall be placed in continuous, approximately horizontal layers having a compacted thickness generally not greater than 1 m. In those areas where the rockfill width is less than 3 m, the un-compacted thickness of the layer shall be reduced to a depth directed by the designer. Successive loads of material shall be dumped so as to secure the best practical distribution of the material and minimize segregation as approved by the designer. The material shall be dumped and levelled prior to compaction.

Rockfill shall not be placed against new concrete until the concrete has been in place for at least 28 days.

(f) Zone 4: Filter, Drain and Transition Zone Materials

Material for horizontal filters and drains may be placed in heaps and then spread with graders.

Traffic shall be controlled with crossings limited to roadways which shall afterwards be removed entirely and replaced with filter material. The layers shall be placed free from contamination by fines and without segregation. Equipment shall not be allowed to operate simultaneously on horizontal filter zones and the adjacent earthfill zones. The material for horizontal filters and drains, such as the blanket drain may be placed and spread in one single layer if in the opinion of the designer adequate homogeneity and compaction can be achieved over the full thickness of the layer.

Inclined and/or vertical filter layers shall be placed to the full specified thickness and in heights not exceeding 500 mm. They may be constructed either by:

- Placing and spreading in advance of the surrounding zones; or
- Placing and compacting the surrounding materials for the full width and then excavating through these layers in order to place the filter material.

In both cases, particular care shall be taken to ensure that any contaminated filter material is completely removed before placing the next layer of filter material.

Filter layers shall at all times be protected against contamination or clogging by materials from other zones, excavated material or material transported by surface or stormwater runoff. Material placed

against irregular surfaces shall be worked into all crevices and openings to ensure that there will be no voids or cavities after compaction.

At the contact with the fill and in the case of vertical or inclined filters the adjoining fill shall be built up and compacted simultaneously with the filters over a width of at least 2.0 m to support and protect the filters. The filter layers shall be maintained at a height of between 300 mm and 500 mm above the level of the adjoining fill, except for the supporting fill which shall be gradually sloped away from the filter to prevent surface runoff from the fill from entering the filters. Where embankments are constructed with joints leaving filter or transition layers exposed or incomplete the Contractor shall ensure that the area enclosed by the cofferdams is kept entirely dewatered at all times until such filter and/or transition layers have been completed over their full length (and thickness if so required by the designer) to prevent contamination and/or clogging of the same. Subsequent partial inundation of the area within the cofferdams shall then also only be permitted as described in the relevant specification.

At the edges of the embankments the Contractor shall take measures to the satisfaction of the designer to prevent concentrations of surface runoff from damaging the transition layers underneath the outermost slope protection layers, which damage shall all be repaired by the Contractor to the designer's satisfaction. Silt or soil fines that may be deposited on these layers as a result of surface runoff from the partially completed embankments shall be removed to the satisfaction of the designer prior to proceeding with the construction of the layer.

The filter and drain material for the toe drain shall be placed in separate layers to ensure that the material below the drain pipe is compacted prior to installation of the drain pipe and that the drain pipe is firmly embedded in the surrounding material.

After laying the drain pipes the remainder of the trench shall be backfilled and compacted by hand compactors in 150 mm to 200 mm thick layers. The materials shall be zoned and comply with the specified classes and grading. The Contractor shall at all times ensure that the drain pipes are not damaged or disturbed and are kept free of dirt or foreign material. The upstream end of any particular leg of drain pipe shall be sealed by means of a suitable end cap as directed by the designer.

After completion of any particular embankment incorporating a toe drain the Contractor shall test the toe drain in sections to the approval and in the presence of the Engineer to ensure that the pipes and joints are clear of all obstructions.

(g) Zone 5: Riprap

Riprap shall be placed on a transition layer / bedding. Unless otherwise directed by the designer, the riprap shall be placed concurrently with the construction of the embankments but kept at a level of approximately 1.0 m below the level of the transition layers but no more than 3.0 m below the level of the embankment fill. The material shall be dumped as a single layer directly into its final position

with a minimum amount of voids and subsequent handling except as may be necessary to finish the slopes to within the specified tolerances. The material shall be placed from the bottom of the slope by dumping from above but without permitting it to roll down the slope. The vehicles containing the riprap may be lowered down the slopes provided that this operation does not cause the underlying material to rut or to be disturbed. The methods adopted by the Contractor shall however at all times be subject to the approval of the designer.

The completed riprap must be a dense, uniformly thick and stable layer. The placement of riprap shall commence in a zone indicated by the designer (generally below the lowest drawdown level). The method of placement to achieve the end product shall be developed in this area to the satisfaction of the designer.

(h) Zone 6: Pervious Backfill

The material shall be handled and placed in such a manner as to prevent segregation. The method of placing pervious backfill shall be subject to the approval of the designer. The pervious backfill on either side of any structures shall be kept approximately at the same level as the placing of the backfill progresses. Pervious backfill shall be placed and roughly levelled off in layers not exceeding 400 mm in depth.

(i) Zone 7: Rock Backfill

The rock fragments shall be placed and spread in layers not more than (varies according to density requirements and gradation) 600 mm thick. Placing shall be performed in a manner to prevent damage to any structures. The method of placing shall be subject to the designer's approval. The rock backfill on each side of a structure shall be kept approximately at the same level as the placing of the backfill progresses.

(j) Zones 8 and 9: Gravel Capping and Downstream Face Protection

After the final grading has been completed, the Contractor shall place and compact the gravel crest surfacing to a total final layer thickness of at least 200 mm. The downstream face gravel protection layer shall be placed by dumping, in a single layer, without permitting any material to roll down the slope and with a minimum amount of voids and subsequent handling to achieve the specified tolerances.

(k) Zone 10: Transition layer / Riprap Bedding

Prior to the placing of a transition zone, the Contractor shall trim the face of the embankment fill material to within the tolerances specified in Clause 16.7. The transition zones shall be placed to the specified thicknesses and at no time shall the top level of the transition layer be more than 1.0 m below the embankment fill level. The material shall be placed from the top of the existing layer and

not be allowed to roll down the slope. The Contractor shall take particular care to ensure that the zoning of the transition layers is maintained and that no contamination or segregation occurs. The fine transition layer shall be placed at a moisture content that is sufficiently low to prevent bulking and shall be tamped by means of hand equipment to a density sufficient to ensure that the material will not slump when saturated. The methods adopted by the Contractor shall at all times be subject to the approval of the designer.

16.6.3.7 Preparation of Material

The Contractor shall use suitable equipment for breaking down oversize clods and lumps of material ensuring that degradation of the material does not occur. Processing by means of such equipment shall continue until the material so treated has been broken down sufficiently to ensure that after compaction the resulting layer shall have a uniform moisture content throughout and be firm, well-bonded and free from nests of segregated or dry materials. During such processing the layer shall be frequently scarified and bladed to ensure that oversize clods and lumps of material are brought to the surface of the layer.

Where a layer is to join into an adjacent compacted layer, the face of the compacted layer shall be cut back to a slope of 1:2 to give a fresh fully integrated and well-bonded contact. The surface of the underlying layer shall be scarified as specified in Clause 16.6.3.6 to ensure complete bonding between two layers.

Where a narrow filter zone of processed material has to be placed, mixing of the filter material on the embankment may be dispensed with provided that it has been thoroughly mixed prior to placing and is homogeneous after placing.

The surface of an underlying layer shall always be scarified as specified in Clause 16.6.3.6 to ensure complete bonding between the successive layers.

16.6.3.8 Conditioning of Material

Borrow material for the embankment core and shells shall be conditioned in an area approved by the Engineer.

Any water required before the material is loaded in the borrow pit shall be added to the material in successive applications by means of suitable irrigation equipment capable of applying the water evenly and uniformly over the area concerned. Water required to be added on the embankments shall be applied in successive applications by means of water tankers fitted with sprinkler bars or pressure distributors that will apply the water evenly and uniformly.

The water shall be thoroughly mixed with the material conditioned by means of ploughs, disc harrows, rotary mixers, motor graders or other suitable equipment. Mixing shall continue until the

required amount of water has been added and until a uniform mixture is obtained before loading or compaction of the material, as the case may be.

The various materials shall have moisture contents controlled to within the specified range, i.e. OMC +2% to OMC -1% or as determined during the construction of the trial embankment. The moisture contents of the materials measured at any time during and immediately after compaction shall not be allowed to vary beyond the limits specified for each particular zone.

Should the materials at any time be too wet, due to rain or any other cause, they shall be harrowed and allowed to dry out to within the specified range of moisture contents before being brought onto the embankment.

16.6.3.9 Compaction

(a) General

Different zones or classes of fill consisting of different materials or having different compaction characteristics or requiring different compaction moisture contents shall be placed, prepared and compacted in independent operations, although these may be conducted simultaneously in order to ensure complete integration and bonding of the zones.

The specified longitudinal and transverse crest cambers shall be achieved over a minimum height of 15 millimetres per millimetre of camber by gradually varying the thickness of the top layers as directed by the designer.

The Contractor shall allow for settlement of the embankment and its foundation during construction.

The Contractor shall not add thin veneers of fill to achieve the required finish.

Compaction shall be carried out by means of compaction equipment determined during the construction of the trial embankment, all to the approval of the designer, due regard being had to the type of material being compacted. The types of rollers to be used and the amount of rolling to be done shall be such as to ensure that the specified densities are obtained, over the full thickness of layer. Vibratory compaction shall be used to supplement any other compaction for layers more than 200 mm thick. Care shall be exercised when selecting the type of compaction equipment and amount of compaction at the specified moisture content to ensure that it will not promote the formation of slickensides or cause poor bonding between layers.

Special care shall be taken to ensure adequate compaction against concrete, masonry, rock, or any other hard surfaces.

In confined places, such as adjacent to instrumentation chambers, where damage by heavy compacting machinery is likely, compaction shall be carried out by power rammers and/or hand operated vibrating compactors.

All compaction and rolling shall be carried out according to a predetermined pattern in a direction parallel to the centreline of the embankment, the rollers commencing at the sides and proceeding towards the centre of the strip being compacted by half lap stages of the roller wheels or drums. The equipment is to travel at a speed that will give optimum compaction per pass.

Compaction of each layer shall be conducted as close to the edge as is safe and practicable provided that sufficient overlap is always given when compacting adjacent layers. The outer shell zones shall be overfilled sufficiently to ensure that all the material to the outer edges of the zones is adequately compacted. During compaction the layer shall be maintained to the required shape and cross-section, and all ruts, holes and depressions corrected by means of frequent blading with self-propelled graders. Care shall be exercised that degradation and segregation of the material does not occur.

Any layer that has softened after it has been compacted due to rain or any other cause shall be re-compacted by the Contractor after being re-worked to its full depth, provided that the moisture content falls to within the specified limits.

(b) Specific Compaction Requirements

(i) Zone 1: Selected Earthfill Materials

The material in this zone shall have a moisture content between the limits specified (or determined during the trial embankment) and shall be compacted to a dry density of nowhere less than 95% of Proctor density. Special care shall be taken to achieve the required densities in areas against concrete, masonry and rock surfaces.

(ii) Zone 2: Unselected Fill Materials

The material for Zone 2 shall have a moisture content between the limits determined during the trial embankment and shall be compacted to a dry density of nowhere less than 95% Proctor density.

(iii) Zone 3: Rockfill for Embankment

When each layer of rockfill material has been placed, the layer shall be compacted by four passes of a vibratory roller. One pass of the roller is defined as “the required number of successive roller one way trips which, by means of sufficient overlay,

will ensure complete coverage of the entire surface of the layer by the roller." Second and subsequent passes of the roller shall not be made until each pass, as defined above, is completed.

The vibratory roller shall be a towed or self-pro-polled and shall have a smooth steel drum with a width not less than 2.5 m, a minimum static weight of 10 tonnes, a minimum dynamic force of 16 tonnes when operating at 1 400 vibrations per minute, and an applied force not less than 13.5 tonnes per m of compaction drum length. Any towed roller shall have at least 90 percent of its weight transmitted to the ground through the compaction drum when the roller is standing in a level position and hitched to the towing vehicle. Rollers shall be operated at speeds not exceeding 2.5 km per hour and shall at all times during compaction be operated between 1 100 and 1 500 vibrations per minute.

Each pass of the roller shall be offset so that the total compaction effort shall be distributed evenly over the entire area. Special attention shall be given by the Contractor to ensure that no additional passes are permitted over the area. The roller will not be allowed to remain stationary on rockfill with the vibratory mechanism operating.

The roller shall not be operated within 3 m of retaining walls with the vibratory mechanism operating. The 3 m strips immediately adjacent to retaining walls shall be compacted by placing rockfill materials with 300 mm maximum dimensions in layers not greater than 450 mm thick, and compacting with four passes made with the vibratory mechanism not operating.

(iv) Zone 4: Filters, Drains and Transition Zone Materials

Compaction of the filter sand for the blanket drain only shall be done with one or two passes of a roller with the vibratory compaction turned off.

Filter sand in the chimney drain shall be loosely placed and saturated without compaction.

In constricted areas such as the toe drain, filter sand in relatively thin layers need to follow the geometry of the toe drain excavation closely without being disturbed during placement of the filter stone and slotted pipes. In these instances the filter sand may be placed moist and compacted to the required line, grade and thickness.

(v) Zone 5: Riprap

Riprap shall be placed without compaction in such a manner to ensure a layer of uniform thickness and evenly distributed material.

(vi) Zone 6: Pervious Backfill

Water shall be added as necessary so that the moisture content is uniformly distributed throughout each layer and sufficient to attain the required relative density of the material in place. The pervious backfill shall be compacted by tampers or rollers, treads of crawler-type tractors, surface vibrators, or immersion vibrators so that the relative density of the compacted material is not less than 70 percent of solid density. The thickness of the horizontal layers after compaction shall not be more than 150 mm if compaction is performed by tampers or rollers; not more than 300 mm if compaction is performed by treads of crawler-type tractors, surface vibrators, or similar equipment; and not more than the penetrating depth of the vibrator if compaction is performed by immersion vibrators.

(vii) Zone 7: Rock Backfill

Rock backfill shall be compacted in accordance with Clause 16.6.3.9.

(viii) Zone 8: Gravel for Downstream Slope Protection

This material shall be placed dry.

(ix) Zone 9: Capping Gravel

Crest gravel shall be compacted to at least 95% Proctor density and to a total layer thickness of at least 200 mm.

(x) Zone 10: Transition Layer / Riprap Bedding

Compaction to be specified by the designer.

(xi) Topsoil

Topsoil shall be lightly compacted when slightly moist by means of tamping or screed bars.

(xii) Grass Downstream Slope Protection

Where the downstream slope of the embankment is to be grassed, the topsoil shall be mixed into the outer 200 mm (min) of the shell zone, moisture conditioned and compacted with the fill material in that zone.

16.6.3.10 Installation of Instrumentation

The requirements for instrumentation to be placed in the embankments to be specified by the designer. The Contractor shall co-ordinate the required activities with his placing / compaction programme for the embankments.

16.6.3.11 Backfilling around Structures

(a) General

No backfilling shall commence until permission to do so have been given by the designer. Embankments shall be constructed simultaneously on both sides of structures to minimize unequal loading.

Trenches and other excavations outside structures shall be carefully refilled and compacted in layers of thickness not exceeding 250 mm un-compacted.

During the placing of each such layer, the fill material shall be well rolled and compacted, sufficient water being added uniformly to ensure that the density specified for the particular zone is achieved. Each layer shall be completed before the next is added.

Fill material shall only be deposited in water in exceptional circumstances (such as to facilitate dewatering) with the prior consent of the designer.

(b) Restricted Working

Where the use of conventional equipment for compacting adjacent to a structure is not possible, the material to be compacted shall be spread in loose layers of thickness not exceeding 250 mm and compacted by means of mechanical hand tampers to at least the density specified for that particular zone.

16.6.3.12 Finishing

(a) Final Grading

On completion of earthworks to the finished level and after completion of backfilling of all trenches, the whole surface shall be graded, shaped, and compacted to final grades and levels.

(b) Gravel Capping

After the final grading has been completed, the Contractor shall place the gravel capping and compact it to a Proctor density of at least 95% and a compacted thickness of at least 300 mm.

(c) Topsoiling

Topsoiling shall be done according to the provisions of Section 47 - Landscaping Rehabilitation.

(d) Grass or other vegetation

Grassing shall be done according to the provisions of Section 47 - Landscaping Rehabilitation.

(e) Pitching of Surfaces

On completion of final grading, designated surfaces shall, where specified, be pitched with stone or other materials of the type and in the manner specified.

(f) Gabions

Where specified, gabions shall be constructed as specified in Section 21 - Gabions and Reno Mattress Structures.

16.7 TOLERANCES

16.7.1 Positions, Levels and Dimensions

Subject to the lines of the completed work being satisfactory to the designer, the following tolerances in Table 16/1 shall apply to the positions, levels, and dimensions of the finished work, due allowance being made for the expected settlement.

TABLE 16/1
DIMENSION TOLERANCES

ITEM	PD FROM DESIGNATED DIMENSIONS, MM		
	DEGREE OF ACCURACY		
	III	II	I
1) Embankment crest level	*	+ 100, - 0	*
2) Horizontal crest width	*	± 300	*

ITEM		PD FROM DESIGNATED DIMENSIONS, MM		
		DEGREE OF ACCURACY		
		III	II	I
3)	Horizontal width of rockfill and earthfill zones	*	± 300	*
4)	Thickness of filter and drainage layers	*	+ 100, - 0	*
5)	Thickness of riprap	*	+ 25% of specified thickness, - 0	*
6)	Topsoil thickness on downstream face	*	+ 50, - 0	
7)	Horizontal position of earthfill zones, filter layers, riprap, and crest	*	± 500	*
8)	Gravel capping	*	- 0, no top limit	*

16.7.2 Moisture Content

Except where otherwise required in terms of the project specific requirements or specifications, the moisture content in at least 90% of the tests shall be within the limits given in Table 16/2 below:

TABLE 16/2
MOISTURE CONTENT TOLERANCES

ITEM		PD FROM PROCTOR OPTIMUM MOISTURE CONTENT, % POINTS		
		DEGREE OF ACCURACY		
		III	II	I
1)	Homogeneous fill material	*	± 2	*
2)	Core zone	*	+ 3, - 1	*
3)	Outer zones	*	+ 1, - 3	*
4)	Random fill material	*	+ 2, - 3	*
5)	Dispersive soil	*	+3, - 0	*

Should the results of the tests on any particular layer or part of a layer of a compacted fill show that the moisture content is not within the appropriate limits given above, the compacted layer or part of the layer shall be harrowed and wetted or dried, as applicable, and re-compacted.

16.8 TESTING

16.8.1 Records

A complete record shall be kept of all embankment operations, which shall cover the location in the borrow pit or excavations, quality and quantity of material placed, the locations of all materials placed, the moisture condition of the material during placing and compaction, the number of roller passes required on each layer to reach the specified compaction, the lengths, widths and thicknesses of the layers and the results of all tests including details of location.

16.8.2 Exploratory Holes

The designer may require the Contractor to drill, auger, or excavate holes in advance of the start of construction to determine founding condition or for other purposes.

16.8.3 Testing by the Contractor

The Contractor shall agree with the designer and Engineer the number of tests to determine the consistency of materials placed in embankments, around and over pipes, and as backfill to structures. In addition, he shall carry out routine compaction control tests to ensure that the specified densities are being attained.

The sampling procedures and sizes of samples for tests shall be as agreed with the designer for each embankment zone and the Contractor shall allow for performing grading analyses on samples of riprap up to 300 mm in dimension.

All Site testing carried out by the Contractor shall be performed in a suitably equipped laboratory and by competent and sufficiently experienced laboratory staff in accordance with the quality control procedures. Off-Site testing shall be carried out by a recognised testing institution or a laboratory approved by the Engineer.

16.8.4 Additional Testing by the Contractor

The Engineer shall have the right to instruct the Contractor to do any additional testing which is required in the opinion of the Engineer.

In addition to the tests specified in SANS 1083 and Clauses 16.8.7 and 16.8.8, the materials shall be sampled and the tests shall be conducted in accordance with the test methods specified in either TMH1 “Standard Methods of Testing Road Construction Materials”, the British Standards Institution, the Procedures for Sampling, Classification, and Testing of Soils and Installation of Instruments of the United States Department of the Interior, Bureau of Reclamation as described in the “Earth Manual” as revised or the American Society of Testing Materials (ASTM) as directed by the designer.

16.8.5 Frequency of Testing

The lot sizes for testing for compliance of filters, drain and transition layer materials and riprap with the requirements of Clause 16.4 shall be twice the lot sizes specified in SANS 1083 for filter, drains and transition layer materials and six times the lot sizes specified in SANS 1083 for riprap except for the riprap grading, which is dealt with hereafter.

At least one field density test for each 1 000 m^2 of each layer with a minimum of 3 tests in any one layer or portion thereof shall be carried out.

Moisture content tests in the borrow pits shall be carried out at a rate of at least one test for each 200 m^3 of material in the borrow pit and also on the embankments at a rate of at least one check test for each 1 000 m^2 of each layer with a minimum of 3 tests in any one layer or portion thereof placed at one time.

Density tests on filter, drain and transition layer materials shall be carried out at a rate of not less than three tests per layer or portion thereof placed at one time or one test for every 1 000m^2 of material placed, whichever is the greater number of tests.

Field density and moisture content tests shall be carried out immediately after the compaction of the section of the layer is completed and in any event not later than 12 hours after the completion of the section of the layer. If such tests are not carried out by the Contractor within this period then the Engineer may at his discretion pass or fail the layer or section of the layer regardless of any soil test results which may then be provided.

Grading analyses and tests on the compaction and other specified physical properties of the materials obtained from the borrow pits or excavations shall be carried out for each zone and/or type of material at frequencies and in accordance with directions from the designer. These tests shall, however, be conducted at a frequency of not less than one for every 2 500 m^3 of material placed and compacted.

For the filters and drains and the transition layers beneath the riprap at least one grading analysis shall be performed for every 500 m^3 of material placed in each zone. For the collector, strip or toe drains at least one sample shall be taken for every 300 m length placed.

Grading analyses on the riprap shall be conducted at a frequency of at least one test for every 5 000 m^3 placed for the first 15 000 m^3 and thereafter every 20 000 m^3.

16.8.6 Soundness Test for Riprap and Rockfill

The basic principles for determining the soundness of the selected riprap shall be SANS 5839, adapted as stated below:

a) Initially the sample shall be broken into an approximately uniform grading and shall be screened. The portion passing the 19.0 mm sieve but retained on the 13.2 mm sieve shall be used in the test;
b) The test sample shall weigh 1 000 grams +/- 2% and shall be washed as described in SANS 5839;
c) The procedure specified in Section 3 of SANS 5839 shall be followed for 5 cycles;
d) The sample shall then be sieved using a 11.2 mm size as defined in Table 3 of SANS 5839; and
e) The percentage loss shall be determined from the mass of the material retained on the sieve and mass of the original sample.

16.8.7 Grading Tests for Riprap and Rockfill

The samples shall be separated into the specified size fractions using suitable standard square mesh screens or individual sizing squares as appropriate.

The dry mass of the materials shall be determined using appropriate platform and other scales.

To assist with the visual control of the riprap and rockfill grading the Contractor shall make up two samples of riprap / rockfill, each up to 15 tonne in mass to the gradings of the coarse and fine limits of the specified riprap and rockfill grading envelope.

16.8.8 Density

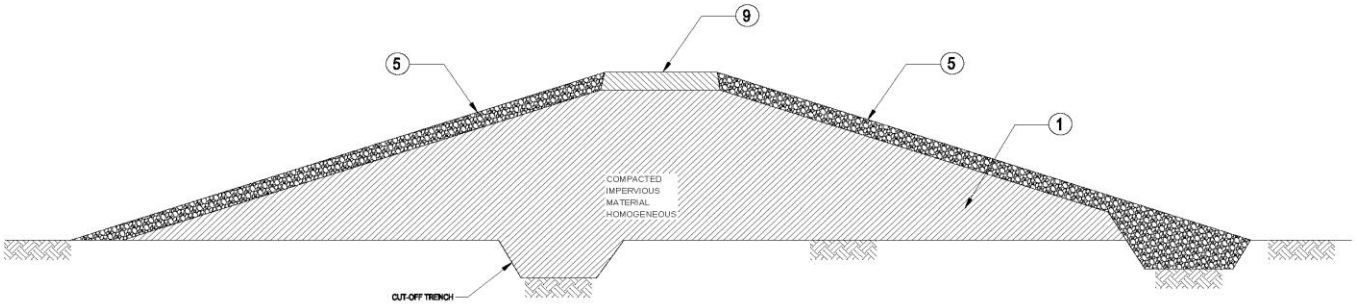
The density of the earthfill shall be measured in accordance with the standard Proctor test (see ASTM D 698).

Should the average Proctor density determined from 10 consecutive routine compaction control tests at random locations in the earthfill fall below the specified density, the Engineer may order that, before further material is placed, the Contractor shall submit a revised compaction procedure for review by the Engineer.

Should the Engineer consider that any area in the earthfill is not receiving adequate compaction he may require specific tests to be carried out.

Should the Proctor density determined in any specific test be more than 5 percentage points below that required for the layer, the material in the area of work represented by that specific test shall be reworked until it complies with the said requirement or it shall be removed from the embankment, as directed by the Engineer.

ANNEXURE 16/1
TYPICAL DAM CROSS SECTIONS SHOWING EMBANKMENT ZONES



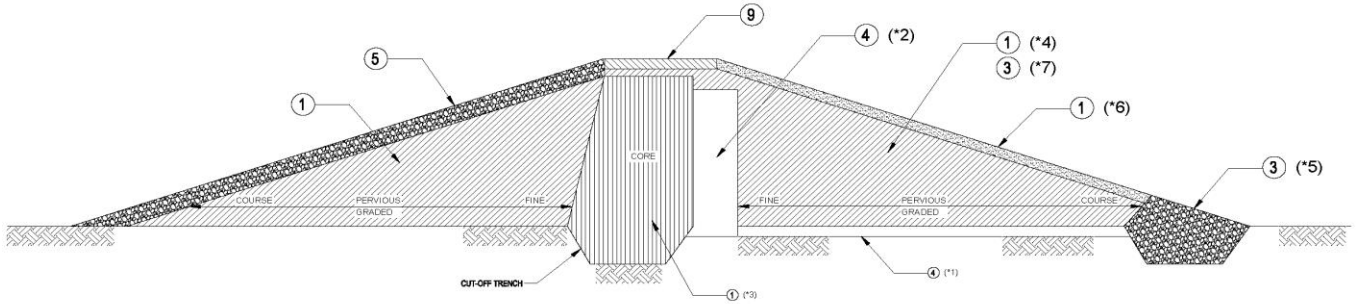
TYPE A CROSS SECTION

NOTES:

1. HORIZONTAL DRAIN.
2. VERTICAL DRAIN.
3. CORE / SELECTED EARTHFILL (IMPERVIOUS).
4. SELECTED EARTHFILL (PERVIOUS / SEMI-PERVIOUS).
5. ROCKFILL TOE.
6. TOP SOIL ON DOWNSTREAM SLOPE.
7. ROCKFILL.

DAM ZONE DESCRIPTIONS

ZONE	MATERIAL
1	SELECTED EARTH FILL.
2	UNSELECTED FILL MATERIAL.
3	ROCKFILL.
4	FILTER, DRAIN AND TRANSITION ZONE.
5	RIPRAP.
6	PERVIOUS BACKFILL.
7	ROCK BACKFILL.
8 + 9	GRAVEL.
10	TRANSITION LAYER / RIPRAP BEDDING.



TYPE B CROSS-SECTION SHOWING

TYPICAL DAM CROSS SECTIONS SHOWING EMBANKMENT ZONES

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 18

DRILLING AND GROUTING

TCTA MODULAR STANDARDS
SECTION 18
DRILLING AND GROUTING

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SECTION 18
DRILLING AND GROUTING

18.1 SCOPE

This Section covers the drilling and grouting of foundations for structures requiring consolidation grouting and/or the management of ground water flow.

The foundation treatment, including jet grouting, forms an integral part of this Section and includes the following grouting processes:

a) Drilling of holes for grouting;
b) Pressure jet-grouting to control water seepage;
c) Pressure jet-grouting for ground improvement;
d) Pressure grouting of rock/concrete interfaces;
e) Pressure grouting of rock fissures and cavities;
f) Testing;
g) Stemming of grout holes; and
h) Cleaning up after grout operations.

This Section shall be read in conjunction with Section MS20: Structural Concrete.

18.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

18.2.1 Definitions

The following terms shall have the following meanings:

a) **"Cavity grouting"** means grouting to fill any voids at rock/concrete interfaces around structures.
b) **"Consolidation grouting"** means the injection of grout into fissured rock below the structure foundations to the depths specified on the drawings.
c) **"Depth"** means the distance from the start of the hole regardless of direction.
d) **"Drain hole"** means the drilling of a hole in the rock to a specified depth and inclination for the purposes of draining water from the rock and preventing the build-up of water pressure in the rock.
e) **"Fissure grouting"** means using patterns of grouted holes in order to seal off water passages intercepting the excavation face or the structure foundations.
f) **"Grouting in descending stages"** means the procedure of drilling a hole to a limited depth, setting a packer and grouting hole and surrounding rock mass, permitting the grout injected to set sufficiently to prevent its entering the hole when the hole is cleaned, cleaning out the hole, drilling the hole to a deeper stage, setting a packer at the bottom of the previously grouted stage or elsewhere as directed by the designer, grouting the new stage, and thus continuing in as many cycles of drilling and grouting as are required.

g) **"Grouting in ascending stages"** means the procedure of drilling a hole to full depth in one operation and grouting from the end of the hole towards the surface in successive stages by setting the packers at predetermined depths.

h) **"High pressure hammer action jet grouting"** means the combined application of high-pressure hammer action drilling and jet grouting. The use of specialised jet grouting hammer heads are required for construction in difficult deep cobble and boulder matrix founding conditions.

i) **"Jet Grouting"** means an in-situ injection technique employed with specialized equipment that includes grout pump(s), grout mixer, drill rig, drill rods and injection monitor with 1,2 or 3 horizontal radial nozzles delivering high velocity fluids to erode, mix, and stabilize in-situ soils and cobbles and boulders as a soil / aggregate cement matrix in the shape of a column.

j) **"Monitor" (adjusted for single, double, and triple systems)** means a single, double, or triple fluid drill pipe attached to the end of a drilling string and designed to deliver one to three elements of the Jet Grouting process, typically air, water, and grout. The monitor has one or more injection points (nozzles).

k) **"Parameters"** means the pressure of the fluid(s) within the jet grouting string; flow rate of the fluid(s); grout composition; rotational speed of the jet grouting string; and rate of withdrawal or insertion of the jet grouting string.

l) **"Soil / aggregate-cement structure"** means a single zone or block of jet grout elements that are partially or fully interlocked as indicated on the drawings. Soil / aggregate cement structures shall be comprised of soil, cobbles and boulders, and cement elements of sufficient pattern and spacing as to stabilize the soil mass within the limits shown on the drawings to meet the performance requirements specified in this Section.

m) **"Stage"** means a partial or complete length of hole in which grouting is performed.

n) **"String"** means jointed rods with simple, double or triple inner conduit that conveys the jet grouting fluid(s) to the monitor.

18.2.2 Abbreviations

ASTM: American Society for Testing and Materials
BS: British Standard
CQC: Construction Quality Control
CSF: Condensed Silica Fume
FA: Fly Ash also known as Pulverised Fuel Ash (PFA)
GGBS: Ground Granulated Blast-Furnace Slag
GGCS: Ground Granulated Core Slag
L: Lugeon
MPa: Megapascal
MQC: Manufacturing Quality Control
PVC: Polyvinyl Chloride
OPC: Ordinary Portland Cement
RHPC: Rapid-Hardening Portland Cement

RPM: Revolutions Per Minute
SANS: South African National Standard
UFC: Ultra Fine Cement
UCS: Unconfined Compressive Strength

18.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard, including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014 and Hazardous substances Regulation.

18.3 GENERAL

The general requirements for drilling and grouting are shown on the drawings. However, the final extent of the drilling and grouting will be determined by the conditions which are encountered during the progress of the work. The number, location, spacing, direction, inclination and depth of the drill holes, the order of drilling such holes, the pressure and mixtures to be used for grouting, the depths at which the grout will be injected, the sequence of grouting holes and the pressures for water testing shall all be as per the Contractor's method statement as reviewed by the Engineer. Decisions on these matters will depend upon the nature of the rock encountered in the excavations.

The drilling and grouting work shall be executed by an experienced team of personnel and adequate equipment for this type of work and monitored full time.

The required procedures as stated in the method statement shall be strictly followed and records shall be accurately kept.

Jet grouting will be utilised to achieve a water leakage barrier by installing overlapping jet grouted columns.

This will be achieved with jet-grouted columns in multiple rows as indicated on the drawings. The jet grouting shall exhibit the following characteristics (Performance objectives):

a) Residual permeability of less than 1 Lugeon, i.e. a permeability (k) < 10^{-7} m/s;
b) The column matrix shall have a minimum Unconfined Compressive Strength (UCS) of 5 MPa;
c) The column grout quality shall exhibit a compressive strength of at least 20MPa at 7-days; and

d) Vertical and horizontal tolerances not exceeding 2% of the length of the column.

The Contractor shall take all precautions necessary to prevent overheating of the grout in order to reduce the possibility of premature initial set.

The Contractor shall provide for the adequate disposal of all wash water and waste grout resulting from all grouting operations. He shall not allow such water and grout to contaminate any fill, backfill or other works, and such water or grout shall not be allowed to flow into any water course until it has passed through settlement ponds or tanks.

Concrete surfaces and foundation surfaces over which grout has flowed shall be cleaned and restored to their original condition.

Upon completion of the grouting, the Contractor shall remove all removable grout nipples from grout pipes embedded in concrete.

18.4 GROUT

18.4.1 Materials

Grout for injection under pressure shall consist of a mixture of Ordinary Portland Cement (OPC), Rapid-Hardening Portland Cement (RHPC), Ultra Fine Cement (UFC), Fly Ash (PFA), Ground Granulated Blast-Furnace Slag (GGBS), Condensed Silica Fume (CSF), water and, where required, sand, or other additives, including bentonite, in proportions determined by the Contractor and as applicable for different applications.

Materials for grouting shall comply with the requirements of Section 20 - Concrete Works (Structural) and in addition, the following clauses:

18.4.1.1 Cement (CEM), Fly Ash (FA) and Condensed Silica Fume (CSF)

Cement shall be type CEM I Class 42.5 N (OPC) or CEM I Class 52.5 N (RHC) or Class 42.5 R (RHC) to SANS 50197-1 and passing a 0.090 mm sieve, and not more than 10% shall be retained on a 0.045 mm sieve. The Blaine fineness shall be greater than 440 m^2/kg. Ultra-fine cement shall have a Blaine fineness greater than 700 m^2/kg.

Fly Ash (Pulverised Fuel Ash) and Condensed Silica Fume shall also conform to the requirements of SANS 50197-1.

18.4.1.2 Sand

Sand shall comply with the requirements of Section 20 – Concrete Works (Structural); except that all sand shall pass a 2.36 mm sieve and not more than 10% shall pass a 0.075 mm sieve.

18.4.1.3 Water

In addition to the requirements of Section 20 – Concrete Works (Structural), water for grouting shall not contain organic matter in suspension or solution and shall contain no particles larger than 80 microns. The temperature of the water immediately prior to the preparation of grout shall be in the range of 5˚ to 35˚C.

18.4.1.4 Bentonite

Bentonite used in bentonite/cement grout shall have a Plasticity Index greater than 400. Test certificates of the properties of the bentonite supplied shall be made available to the designer for review. When mixed with water the bentonite shall not contain any particle larger than 75 microns and shall not contain any substance detrimental to the setting and hardening of the bentonite/cement.

The Contractor's arrangement for delivery and storage of bentonite shall comply with the requirements of Section 20 - Concrete Works (Structural) referring to the delivery and storage of cement.

The bentonite/water slurry base shall be prepared in advance using cement-free water in a high turbulence (colloidal) mixer and shall be kept agitated in a large container for at least 24 hours. Mixers used for grout shall not be permitted to mix the bentonite/water slurry.

18.4.1.5 Admixtures

Admixtures used shall comply with ASTM C-494, ASTM C260 or BS EN 934. Admixtures, such as plasticisers, accelerators and retarders, may be used only as directed by the designer. In support of the request for the use of an additive the Contractor shall submit the results of relevant laboratory tests demonstrating the effectiveness and advantages of the product.

18.4.2 Testing

The Contractor shall provide Marsh flow cones, thermometers, mud balance and measuring cylinders (60 mm diameter) to check the consistency of the grout at any time. The applicable limits shall be jointly established by laboratory and field tests prior to work commencing.

18.4.2.1 Relative Density (Mud Balance)

Determination of the relative density of freshly mixed grout shall be with a mud-balance. Measurements of relative density read directly from the calibrated beam shall be converted to a water cement ratio by means of an agreed curve or table.

18.4.2.2 Viscosity (Flow Cone)

The fluidity of grout shall be measured with a flow cone, immersion apparatus or viscometer. The instrument shall be accurately calibrated in a laboratory so that the specified viscosity of the grout can be controlled satisfactorily.

The procedure for conducting the flow-cone test for measuring the fluidity of grout shall be as follows:

a) Immediately after the grout has been mixed, the pre-wetted flow cone, which is held firmly with its top rim in a level position, shall be filled with grout to the level indicated by the pre-set pointer, whilst the bottom orifice is held closed with a finger;
b) As soon as the required volume of grout, (± 1 750 mℓ), is reached, the finger shall be released to allow the grout to flow out freely through the bottom orifice. A stopwatch shall be used to determine the flow time for emptying the cone, to the nearest second; and
c) The readings obtained during grouting shall be compared with the times determined in the laboratory for grouts of the specified viscosities.

18.4.2.3 Bleeding

The bleeding of grout shall be measured in a metal or glass container with an internal diameter of approximately 100 mm and a height of approximately 120 mm. The grout and water levels in the container shall be controlled with a metal bridge into which two adjustable studs A and B are secured.

The procedure for determining the bleeding of grout shall be as follows:

a) Studs A and B in the metal bridge shall be adjusted and locked so that the distance from the lower tips of the studs to the bottom of the container will be approximately 100 mm and 107 mm respectively. The volumes V_A and V_B for the container at the respective levels of the stud settings shall then be determined to the nearest millilitre;
b) The container shall be filled with freshly mixed grout to a level where the grout will just touch the tip of stud A which points downwards. The bridge shall then be removed and the container tightly sealed to prevent evaporation. The container shall then be stored at 20^{o}C and kept free from vibrations for the entire duration of the test;
c) Three hours after the grout has been mixed, the container shall be opened and the free (bleed) water poured off. The bridge shall be placed over the container with the tip of stud B pointing downwards and water poured onto the grout with a measuring apparatus until the water level touches the tip of stud B. The volume of water added shall be determined to the nearest millilitre and designated as ΔV; and
d) The percentage of bleeding shall be calculated from the formula:

$$100 - \{(V_B - \Delta V)/ V_A\} \times 100$$

18.4.2.4 Test Cubes

Samples of grout shall be taken by the Contractor at the point of mixing at each grout mixing station or of deposition, all in accordance with the sampling procedures described in SANS 5862.

Samples shall be taken on the basis of one for each 50 m^3 of grout pumped but, in any case, not less than one sample per day per mixing station.

The Contractor shall cast from each sample, cure and test six test cubes as set out in SANS 5863. Three (3) cubes shall be tested at 7 days and three (3) cubes at 28 days.

The average strength of the 3 cubes crushed shall be referred to as one test result.

Grout shall be deemed to comply with the strength specified if the average strength of any 4 consecutive test results exceeds the agreed characteristic strength by 2 MPa and the strength of any test result is not less than the specified characteristic strength minus 3 MPa.

The quantity of grout represented by any group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches. When a test result fails to comply only the particular batch from which the sample was taken shall be deemed to fail to comply.

The Contractor's methods of sampling, making of cubes and testing shall not be considered as a valid reason for rejecting the results of such tests on grout placed in the Works. Should test results fail, the remedial measures referred to in Section 20 - Concrete Works (Structural) shall apply.

18.4.2.5 Jet Grout Cores

Cores shall be taken from at least 10% of the jet grouted columns to test compressive strength as well as consistency. The drilling, core recovery and preparation and compressive testing shall comply with SANS Method 865. The positions of the core sampling shall be agreed with the designer.

18.4.3 Mix

The grout mix is specified as the ratio of water to cementitious material by mass. In principle a single grout mix shall be used for the consolidation grouting and/or grout curtain irrespective of depth of hole and location. However, the Contractor may require a thicker mix for use in zones of high take and a thinner mix for special cases. In case of major absorptions, a cement mortar mix approved by the designer can be used. The Contractor may, however, propose an admixture to render the grout thixotropic instead of using sand.

The appropriate grout mix shall be determined on the basis of grout tests prior to the commencement of the trial panels.

In carrying out the laboratory tests the mixing equipment to be used on the grouting works shall be used. Bentonite slurry shall be prepared as specified above.

Any grout which does not contain a retarder and has not been used within one hour of the time of mixing shall be discarded and disposed of.

Initially, grout tests shall be carried out on mixes with water/cement (W:C) ratios of 0.8:1, 0.7:1 and 0.6:1, aiming to provide stable mixes with less than 5% settlement at 2 hours and Marsh cone values of about 35 seconds. Admixtures may be used to reduce Marsh Cone values.

Compressive strengths at 7 days shall be greater than 20 MPa on 100 x 100 x 100 mm cubes cured under water. One set of cubes shall be tested per day until consistency of results allows testing intervals to be increased.

All grout shall be mixed in a high speed colloidal mixer for at least 1½ minutes from the time the last constituent is added to the mixer.

During grouting operations the following routine tests in accordance with Clause 18.4.2 shall be performed at the collar of the hole:

- Density - Mud balance test
- Viscosity - Marsh Cone
- Bleeding - 60 mm diameter measuring cylinder

The Contractor shall make arrangements for a location close to the hole being grouted where the bleeding test will not be disturbed.

18.5 EQUIPMENT

18.5.1 General

The Contractor shall provide sufficient drilling and grouting equipment and all necessary ancillary equipment, scaffolding and other accessories to complete the various types of drilling and grouting required.

The use of internal combustion engines for grouting in shafts will not be permitted.
For jet grouting applications all equipment used for drilling boreholes; lowering, raising and rotating jet monitors; mixing grout; supplying pressurized grout and air-water to jet monitors; and jet monitors shall have proven performance records for use in jet grouting work. Where required in difficult formations, a combination of a down-the-hole hammer with an integrated jet monitor enabling drilling and jet grouting shall be used.

18.5.2 Drilling Equipment

18.5.2.1 Percussion Drills

Percussion drills shall be provided with a water supply at a minimum pressure of 8 bar at the drill, when all equipment on the same supply is operating together.

Rotary-percussion drilling equipment will be required that is capable of advancing a steel casing through overburden simultaneously while drilling through soil and rock and allowing the drill string to be withdrawn through the casing.

The circulating/flushing medium shall be high-pressure water. Air flushing will only be permitted in exceptional circumstances, subject to the designer's approval.

Drilling with side-discharge bits will not be permitted for conventional percussion drilling.

For jet grouting applications, drilling equipment of a type and capacity suitable for drilling required hole diameters and depths, and lowering, raising, and rotating jet grout monitors to the depths and at the rates required. The drill rig shall be equipped with automated controls to regulate and maintain consistent rod retraction rate, rod RPM and have pressure gauges for all fluids injected.

18.5.2.2 Diamond Drills

A limited number of holes will require rotary diamond drilling with coring in rock or jet grouted concrete. The core diameter should not be less than BX size, and the diameter of the drilled hole and the steel casing through the overburden should be compatible with the pneumatic packers specified. In the case of the jet grouting cores the minimum diameter of 65mm is determined by SANS Method 865.

18.5.3 Water Testing Equipment

The water testing equipment should comprise a water tank, a progressing helical cavity pump (i.e. Mono type), a pressure hose, two pressure gauges capable of operating independently (one calibrated in kilopascals with a maximum capacity of 1000 kPa in 20 kPa divisions, the other calibrated in bars with a minimum capacity of 20 bars in 1bar divisions), a water meter calibrated in litres with 0.1 litre divisions, a bypass valve for pressure control, a pneumatic packer, and a nitrogen bottle and hose.

18.5.4 Grouting Equipment

18.5.4.1 General

Grouting equipment shall be capable of effectively batching (with an accuracy of better than 2% for batching by volume or mass), and producing a colloidal mix as specified, and of delivering and pumping grout into the grout holes through grout connections in a continuous uninterrupted flow at

any constant pressure up to the limiting pressure specified.

The arrangement of the grouting equipment shall be such as to provide a continuous circulation of grout of uniform consistency throughout the grouting system and to permit accurate pressure control at the collar of the hole being grouted at all rates of grout acceptance. Pressure gauges and valves shall be supplied at the pump, at each hole being grouted, and elsewhere as required to ensure the necessary control of grouting operations. In the case of all grouting activities automatic pressure/time and flow/time and total volume chart recorders shall be connected at the collar of each hole being grouted. A new chart shall be used for each hole injected. All grouting circuits shall be so designed as to provide a return line from the site of injection to the holding tank such that a continuous flow of grout is maintained in the delivery line between the grout pump and the collar of the hole being injected.

Grouting equipment shall be to the minimum requirements below and shall include all associated valves, water flow meters, pressure hoses, pipes, sleeves, packers, fittings and small tools necessary to complete the grouting as specified.

Constituent materials of the grout shall not segregate during transportation.

For jet grouting applications the Contractor shall use grout mixers and holding tanks, water tanks, air compressors, and pumps of sufficient capacity to ensure adequate supply of grout, air, and water at required pressure to the jet grouting monitors during a full work shift to produce grout elements of the quality and dimensions necessary.

In general grout mixers shall be high shear type and shall be equipped with load cells to accurately weigh and proportion each component of the grout mix for low flow applications. Under no circumstances shall paddle type mixers be utilised.

18.5.4.2 Pumps

Grouting pumps shall be double acting reciprocating, with pressure damping cylinder, positive displacement screw-feed or other suitable type of pump.

The rate of pumping shall be readily and accurately adjustable from zero flow to the maximum capacity. Equipment shall be such that grout consistency can be adjusted without causing an interruption that could result in setting of grout before pumping is resumed.
Pumps shall be equipped with quick acting lubricating plug valves and accurate pressure gauges, reading in bars. Pumps shall be fitted with automatic pressure relief valves.

Grout pumps shall be capable of pumping grout at a water/cement ratio of up to 1:3 as well as grout containing other materials such as bentonite, sand or other chemicals.

Jet-Grouting pumps shall be capable, with the nozzles proposed, of providing the required velocity and a delivery rate required for the execution of the work.

18.5.4.3 Mixers

Grout mixers shall be of the high-speed colloidal type, with a minimum of 1200 rpm, designed primarily for mixing grout materials, including grout to which sand or additives have been added if required, and of sufficient capacity to ensure that the pumps are supplied with a continuous flow of thoroughly mixed grout.

18.5.4.4 Jet Grout Mixing and Injection Equipment

The Contractor shall use grout mixers and holding tanks, water tanks, air compressors, and pumps of sufficient capacity to ensure adequate supply of grout, air, and water at required pressure to the jet grouting monitors to produce grout elements of the quality and dimensions necessary.

18.5.4.5 Injection Manifold (Header)

The header should be equipped with two full-flow ball valves, one valve located on the return circulation side of the header to divert grout flow into the hole, while the other is located on the hole side of the header to control the pressure when the return valve is fully open.

A union and a shut-off valve should be placed between the gauge and the hole to allow the grout lines to be removed when refusal pressure is reached, while maintaining pressure on the hole.

18.5.4.6 Tanks

Tanks for holding grout between mixing and grout injections shall be of the double drum type equipped with mechanical agitators capable of maintaining the solids of the grout in suspension. The feed into the tanks shall be equipped with adequately sized screens to remove any hardened grout or foreign material larger than 1 mm from grout entering the tanks from the mixers and from the grout return lines. The capacity of the holding tanks shall be not less than that of the grout mixer and the tanks shall be fitted with a graduated dipstick or gauge glass which is capable of recording the volume of grout contained in the tank to within 2 litres.

18.5.4.7 Water Meters

Meters for the measurement of water to be used in grout mixes shall be large faced with adjustable volume markers graduated to read to an accuracy of one tenth of a litre at all rates of flow.

18.5.4.8 Flow Meters

Integrating flow meters capable of measuring volumes of grout injected during grouting operations to an accuracy of ±2% shall be coupled to each grout pump.

18.5.4.9 Pressure Gauges

Pressure gauges shall be capable of reading to an accuracy of 0.10 bars and shall be equipped with devices which will protect the mechanism of the gauge from being damaged by grout. The gauges shall have a range of approximately twice the expected maximum pressure for the particular hole and shall have an accuracy of ±3%.

Gauges shall be provided at the grout pump and at the point of injection.

The Contractor shall have an accurately calibrated high-precision pressure gauge for checking the accuracy of all pressure gauges used in the grouting system.

A certified pressure gauge for calibration of working gauges and a 100% replacement stock of working gauges shall be on hand at all times. Working gauges shall not be used for longer than two shifts, hereafter they shall be cleaned and calibrated. All working gauges shall be marked with a number for identification.

18.5.4.10 Chart Recorders

Pressure/time chart recorders shall have a one-hour time period and a pressure range of approximately twice the maximum specified pressure.

Chart recorders shall be connected at the collar of each hole such that the pressure in the hole is continuously recorded throughout the injection period.

18.5.4.11 Packers

Packers shall consist of pneumatic or hydraulic expandable tubes which can be set singly in a grout hole at any depth required. Packers shall be so designed that they can be expanded to seal the holes at the specified depths and that when expanded they shall be capable of withstanding without leakage, water pressures equal to the maximum grout pressures to which they will be subjected.

The Contractor shall also have double packers of the pneumatic or hydraulic type at least 1 m in length available for use when required.

18.5.4.12 Sleeve Pipes

In areas where grouting is to be carried out through concrete, PVC sleeves will be required through which drilling can be undertaken and into which packers can be installed or to which grout connections can be made.

18.5.4.13 Grout Stops

Geofabric grout stops shall be provided in locations where grout may escape to surface during grouting and where grouting is to be undertaken in compartments.

18.5.4.14 Grouting Delivery Lines

All grout pipes, hoses and fittings shall be capable of withstanding a pressure of 5 bars and shall be protected from damage or breakage by vehicles, equipment, blasting operations, freezing and the like. A return line shall be provided for flushing hoses, to control the rate of pumping and for emergency pressure relief. These return lines shall be connected to the pump side of the recorder gauges at the collar of the grout hole and shall discharge into the holding tanks or to waste containers only. The Contractor will not be permitted to discharge grout without such collectors.

The length of grouting hose from the grout pumps to the hole to be grouted shall not exceed 300 m.

18.6 DRILLING PROCEDURES

18.6.1 General

The position, direction, inclination, spacing, depth, order and timing of drilling holes for drain holes or grouting, shall be as shown on the drawings or as directed by the designer. The holes shall be drilled straight in the required direction and inclination, and the length of holes shall be established by reference to the collar level and profiles recorded by the Contractor. Descending stage drilling and grouting will be executed in rock, the maximum stage length being 5 metres.

Unless otherwise specified by the designer, holes shall be started within 250 mm of the specified position or plan or section and shall be drilled in the direction specified within a tolerance of 2% of the length of the hole. No hole shall be deepened or drilled within 5 m of freshly grouted holes until the designer is satisfied that the grout in the rock adjacent to the hole has set sufficiently to prevent it being washed into the hole.

Where water return drops below 50%, drilling shall be stopped and the hole grouted to within 0.5 metre of the point where water loss occurred. The same applies when artesian conditions are encountered, or surface leakage occurs. Caving zones should be grouted after each drill run when they are encountered. Under all of these conditions the normal descending stage grout injection procedures and thickening sequence specified should be followed, and on no account should the hole be stemmed with a thick grout immediately on these conditions being encountered.

Holes shall be drilled wet and a constant flow of return water, sufficient to ensure that all drill grindings and sludge are completely washed out, shall be maintained at all times. The Contractor will not be permitted to use rod lubricants or other additives to the drilling water as an aid to drilling or stabilising the holes.

Where packers are to be used in any hole for grouting or water testing, the Contractor shall take every precaution to maintain a smooth wall in the hole in order that packers can be set at any location required by the designer.

The Contractor is to ensure that holes are protected against contamination by waste grout, soil, etc.

18.6.2 Holes through Concrete

Where holes are required through concrete, the Contractor will be permitted either to drill the holes or shall embed PVC sleeves in the concrete through which the rock behind can be drilled.

No drilling shall be carried out in concrete less than 7 days old.

In the case of reinforced linings, the formwork shall be marked by means of plugs or other suitable manner to indicate positions where drilling may be carried out without obstruction by reinforcement.

Should steel reinforcement be encountered during the drilling of any hole in concrete, drilling shall be discontinued immediately, and a new hole shall be drilled alongside. Such discontinued holes shall be stemmed as specified in Clause 18.11.

18.6.3 Percussion and Rotary Core Drilling

Percussion drilling shall be used for cavity grout holes and reinforcement anchors, dowels and rock bolts.

Percussion holes shall be flushed clean in terms of Clause 18.6.5.

All holes shall be drilled within the specified tolerances.

A limited number of holes will require rotary diamond drilling with coring in rock. The core diameter should not be less than BX size, and the diameter of the drilled hole and the steel casing through the overburden should be compatible with the pneumatic packers specified.

18.6.4 Drainage Holes

Drain holes shall be drilled by percussion drilling and flushed clean. The holes shall be drilled to the diameter and in the direction, inclination and location as specified.

Drainage holes shall not be drilled until all grouting required within the vicinity has been completed successfully.

18.6.5 Washing, Protection and Identification

When drilling of a grout or drain hole has been completed to its final depth, the hole shall be washed with high pressure water to remove all drill cuttings, sediments, sludge and other loose or foreign materials until the return water is clear, and all downward holes shall be left filled with water to the surface, or to such level as the water will stand.

Each grout hole shall be protected from becoming clogged or obstructed until it is grouted and, where a grout pipe or standpipe is permanently embedded in rock or concrete, the Contractor shall provide a suitable cap to keep the hole sealed. Whether or not a grout pipe or standpipe is used, any hole which becomes obstructed before being grouted shall be cleared or re-drilled.

Each grout hole shall be numbered to permit identification of each hole at all times until grouting and checking has been completed in the area.

18.6.6 Loss of Holes

Should any hole become clogged before its intended purpose has been fulfilled and cannot be cleared or re-drilled, it shall be replaced.

Abandoned holes shall be washed out and grouted.

18.6.7 Pattern and Sequence for Grout Curtain

The primary hole spacing shall be as shown on the drawings, the holes serving initially as exploratory holes to confirm the need for more extensive grouting.

After completion of water acceptance tests and grouting of the primary holes, secondary holes will be drilled midway between primary holes, then tested and grouted if the test results exceed 1 Lugeon. This split-spacing sequence will be continued to tertiary holes, quaternary holes etc. until the required reduction in permeability (<1 L) is achieved. Within any section of the curtain being grouted, no secondary hole will be drilled until the primary holes on either side have been grouted and the initial set of the injected grout has taken place. The same restrictions apply to higher order holes.

18.7 WATER PRESSURE TESTING

In all holes each grouting stage is to be preceded by a water acceptance test, primarily to determine whether or not grouting of that stage is necessary.

The Lugeon value for each test is determined as follows:

$$\text{Lugeon value} = \text{water take in litres/metre/minute} \times \frac{10 \text{ bars}}{\text{Test pressure in bars}}$$

18.7.1 Five-minute Test

A single five-minute test for each grouting stage (or packer setting) will be sufficient in most cases. At any packer setting water is run into the hole to verify that a tight seal has been achieved at the required pressure for that stage. A start reading is then taken at the water meter and at each minute thereafter for a total of five minutes, while the required pressure is maintained. The test period should be shortened if open hole conditions are found. The test result is reported as a Lugeon value.

During ascending stage grouting, succeeding higher stages can be tested immediately after the back-pressure has dissipated following completion of grouting of the preceding stage.

If it is not possible to seat the packer at the desired depth when grouting in ascending stages, the location may be adjusted upwards in 0.5 metre increments to a maximum of 2 metres above the planned depth, after which a longer soft rubber packer should be used. Where the water is bypassing the packer in highly fractured rock, in which case it will be necessary to raise the packer to a point above the fractures. If this condition persists during ascending stage grouting, it will be necessary to execute the drilling, testing and grouting operations in descending stages.

18.7.2 Fifteen-minute Test

In order to determine whether void-filling, washout or foundation uplift is occurring, it will be necessary to conduct a fifteen-minute test. After the final reading of a five-minute test, the pressure is reduced to zero and the test repeated for a second and third time. The test result is reported as three Lugeon values.

18.7.3 Comprehensive Lugeon Test

Where required, the test entails recording the water take over a period of ten minutes at low pressure, then at medium pressure for the same period, then at high pressure for the same period before repeating at medium pressure and finally at low pressure. Start and finish readings are taken on the water meter at each pressure stage and the constant pressure for the stage is recorded. Pressures are not reduced to zero between increments. The test result is reported as a single Lugeon value after interpretation of the five individual Lugeon values.

18.7.4 Acceptance Criteria

Any stage drilled that has a water test result above 1 Lugeon shall be grouted. This applies to all holes, i.e. primary, secondary, etc.

18.8 GROUTING METHODS

18.8.1 Grouting Procedures

18.8.1.1 General

Grouting will generally be undertaken with a stable mix to be determined in the laboratory (see Clause 18.4).

Careful control of pressures will be required during grouting as excessive local pressures could crack or buckle the concrete or hydro-fracture the rock. Pressure chart recorders shall be used during all such injections. Pressures shall be limited to those specified for each section of the Permanent Works and specific grouting procedures. At no time shall grout from any one pump be injected into more than one hole at a time.

Equipment for mixing, holding and pumping the grout shall be kept as close as possible to the area being grouted and all pipelines and hoses between such equipment and the area being grouted shall be protected wherever necessary to reduce temperature build-up in the lines and the grout.

Grouting of any drill hole within 20 m of a concrete structure or which extends through concrete shall not start until the foundation concrete in the structure is a least 14 days old.

In the event of drilling water ceasing to return (total or partial water loss), drilling shall be interrupted, the packer placed one metre above the leak and the hole grouted irrespective of depth reached, and drilling resumed.

During grouting the Contractor shall take every precaution to prevent the grouting equipment and lines from becoming blocked. He shall accordingly continuously circulate the grout and periodically flush the system with water.

After grouting each scheduled hole, the remaining neighbouring hole shall be cleared of grout by washing or re-drilling as soon as the grout in the rock adjacent to the hole has set sufficiently to prevent it being washed into the neighbouring hole. Re-drilling required to clear the grout in a hole completed prior to re-grouting shall be performed by the Contractor.

If a hole absorbs an abnormal amount of grout without reaching the maximum specified pressure the Contractor shall inform the designer immediately and the rate of injection shall then be reduced, or injection shall be carried out intermittently or such other procedure as may be agreed with the designer shall be adopted.

While grouting is proceeding the Contractor shall watch for leakage of grout or other untoward happenings. Grout leaks shall be caulked but if this cannot be achieved and the leaks are excessive, grouting shall be stopped and resumed later when the grout already injected into the leaking fissures has hardened. Where necessary, level reference points, upheaval gauges, etc. shall be used to be observe as a check against uplift. Any appreciable movement shall be taken as an indication that the grout pressures being used are excessive and they shall be immediately reduced.

The Contractor’s grouting programme shall be such that there is no risk of permanent drains such as pipe drains, or pressure relief drains being blocked by grout. All grouting works shall be completed in any area before permanent drains or drain holes are constructed.
If the pipework or any other part of a drainage system becomes blocked by grout, injection shall be stopped and the whole system shall immediately be flushed out with clean water and all grout removed before injection is recommenced.

The temperature of the grout during mixing and grouting shall not exceed 30ºC or be lower than 10ºC.

In general, no holes shall be left open whilst other holes in the vicinity are being grouted. The number of holes to be drilled at any time shall therefore be limited to the number which can be grouted simultaneously with the equipment provided. When drilling is interrupted or completed, holes shall be fitted with removable plugs or caps to prevent the ingress of foreign matter. Where necessary a steel pipe shall be securely grouted or caulked into the hole and shall be protected by a screw cap.

Upon completion of the grouting all concrete, steel or foundation surfaces over which grout has flowed shall be cleaned and restored to their original condition.

All grouting operations shall be monitored by the designer.

18.8.1.2 Surface Leaks and Inter-hole Connections

If, during the grouting of any hole, grout is found to flow from nearby grout holes the holes shall be left open until the grout emerging is of the same consistency as the grout being injected whereupon the holes shall be closed and injection continued to completion, provided the pressure in the interconnected holes does not exceed the maximum pressure specified for those holes.

If, during the grouting of any hole, grout is found to flow from cracks and fissures in the rock surface, such flows or leaks shall be plugged or caulked by the Contractor. The Contractor shall have available on Site at all times sufficient wooden wedges, sacking, lead wool and other materials which can be used to seal surface leaks.

18.8.2 Curtain Grouting

18.8.2.1 Descending Stage Grouting

Descending stage grouting is used where the rock is weak or highly fractured and needs to be consolidated at higher levels before grouting the lower levels at high pressures. This entails drilling the grout hole to a specified limited depth, placing a packer at the top of the hole and grouting prior to drilling the hole to a greater depth and repeating the process. The grout is usually washed out of the hole after initial set to minimise re-drilling. The packer for succeeding stages will be set at the top of the preceding stage, and not at the top of the hole.

Descending stage grouting in fractured rock is conducted in a series of steps in which the entire split-spacing sequence is completed to closure for the stage being grouted before any hole is deepened. Deepening to each lower stage is stepped back by a distance equal to the primary hole spacing, i.e. the area covered by the final (deepest) stage is smaller than the area of the first (highest) stage.

Should preliminary results indicate that conditions are less severe than anticipated, the designer may order that only the first stage be executed by descending stage, after which the hole may be drilled to the full depth and the remaining stages be done by the ascending method.

18.8.2.2 Ascending Stage Grouting

In strong rock or in rock being grouted below deep overburden, the Contractor may use the ascending method, if approved by the designer.

The hole is drilled continuously to the full planned depth prior to water testing and grouting. Water testing and then grouting commences with the packer placed at the top of the lowest grouting stage. When this stage has been water tested, grouted to refusal and the backpressure has dissipated, the packer is raised to the top of the next stage up and the process repeated.

In order to prevent clogging of fine fissures by thickened grout remaining in the packer pipe following completion of the preceding stage, the packer pipe and the upper part of the grout hole should be flushed with water each time the packer is released preparatory to being raised to the next setting position.

18.8.2.3 Mixing

The correct quantity of water should be metered into the mixer and, if bentonite is being used, the required quantity of bentonite should be sifted slowly into the water while the mixer is operated at full speed. Mixing should continue for at least 5 minutes* to achieve optimum dispersion and hydration, before adding the cement in a similar manner. The pump should then be kept at full speed for not more than one minute** before discharging through a screen into the agitator.

**Adding cement to the bentonite slurry will "kill" the hydration of the bentonite, so it is very important to allow sufficient mixing of the bentonite and water before the cement is added.*

***The mixing time of cement should not exceed 1 minute, nor should the colloidal mixer be used as an agitator, because sufficient heat is generated in the colloidal mixing process to cause premature hydration of the cement. This may prevent the grout from setting properly after injection.*

18.8.2.4 Grout Injection

The following stable bentonite-cement mixes are to be used. Bentonite must be hydrated in the high-speed colloidal mixer for 5 minutes before the OPC is added:

2:1 Mix:	120 litres water	+ 3 kg bentonite	+ 50 kg OPC
1:1 Mix:	70 litres water	+ 3 kg bentonite	+ 50 kg OPC
1:2 Mix:	45 litres water	+ 3 kg bentonite	+ 50 kg OPC

After carrying out the water test, the water should be chased out of the circulating hoses with grout and injection of the thinnest grout mix commenced (water: cement ratio = 2:1 by weight). The volume of grout injection and the mix injected should be recorded at regular intervals. Unless refusal pressure is reached first, additional OPC should be injected at 2:1 as per below before thickening to 1:1, regardless of how rapidly the hole accepts grout.

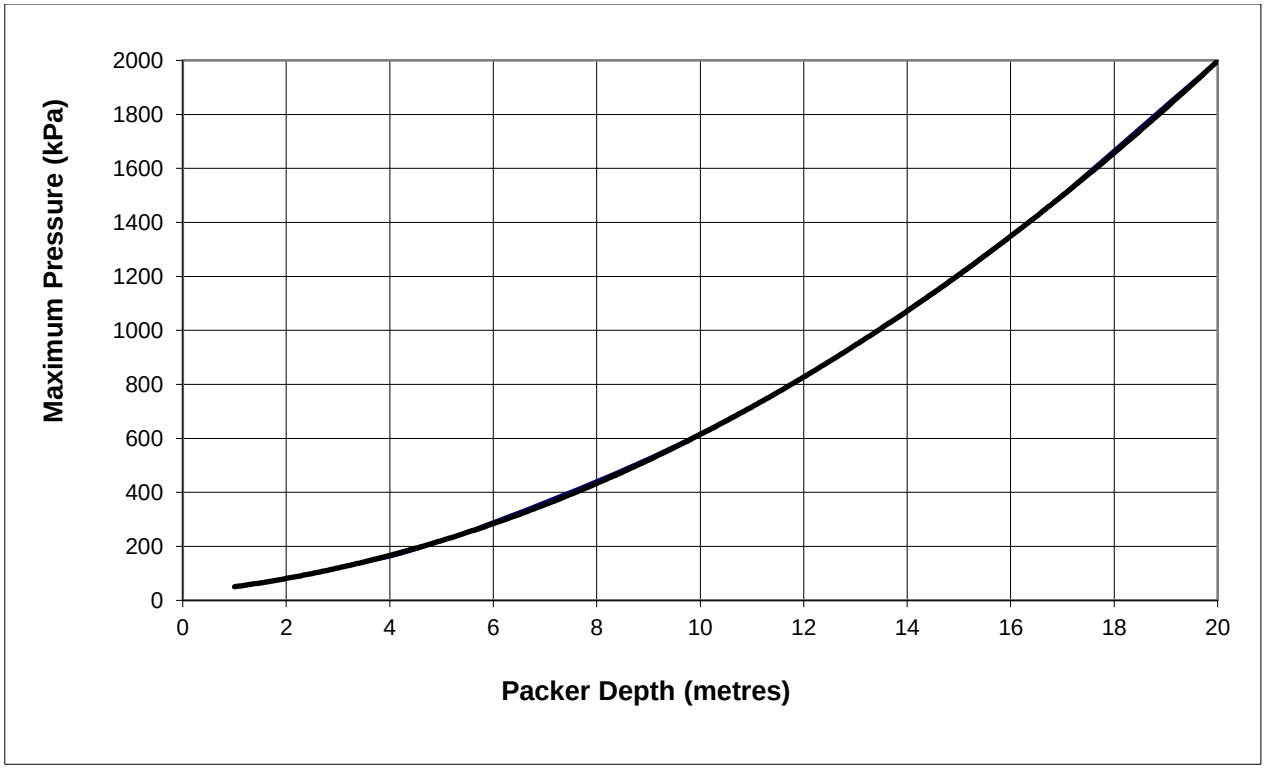
Unless otherwise specified by the designer, the quantity of each mix injected into any stage before thickening to the next mix should be:

2:1 Mix: 2 X 50 kg OPC per metre of stage length, or refusal pressure.
1:1 Mix: 10 X 50 kg OPC per metre of stage length, or refusal pressure.
2:1 Mix: 20 X 50 kg OPC per metre of stage length, or refusal pressure.

If, after this, refusal pressure for the stage has not been met, the hole should be flushed with about 200 litres water, and injection resumed after the grout has set.

18.8.2.5 Injection Pressures

The required pressures for different packer depths may be varied depending on rock condition, overburden thickness and type, etc. The following injection pressures should not be exceeded.



18.8.3 Cavity Grouting

Cavity grouting will be required between the jacked concrete pipe sleeve and the in-situ material. The extent of the cavity grouting operation depends largely on the type of material and the excavation methods applied.

Potential voids shall be continuously detected and recorded at the face of the jacking operation. The Contractor shall determine the number and spacing of air release holes to be drilled from inside the concrete sleeve pipe and the bleed-pipes and bleed valves to be inserted.

Cavity grouting shall be carried out in the sequence and using suitable mix proportions and pressures determined by the Contractor. Generally, injection of grout shall be commenced at the lowest point to allow air and water to be displaced. When interconnections occur, the holes shall be kept open until emerging grout is of the same consistency as the grout being injected, after which the holes shall be closed. Typically, a 1 cement: 2 sand mixture at a water/cement ratio of 0.60 or other mix as determined by the Contractor shall be injected. Injection shall continue until the hole refuses to accept grout at the specified maximum pressure. The grout take shall be measured and compared with the total void volume recorded. If there are indications that the cavity grouting is not complete at the hole spacing adopted, additional holes shall be drilled and grouted.

Unless the holes are subsequently required for other grouting, they shall be completely filled in accordance with Clause 18.11.

18.8.4 Consolidation Grouting

Generally, consolidation grouting shall not proceed in a section until the grout injected in the cavity or proof grouting stage has been allowed to harden and shrink for a period of three days or such lesser period as may be agreed by the designer depending on the magnitude of the grout takes recorded during the cavity or proof grouting operation.

In order to carry out individual hole consolidation grouting the percussion holes used for cavity grouting, or the preformed grout holes in the segmental lining shall generally be re-drilled and extended into the surrounding rock to the depths specified. Where no cavity grouting has been specified to precede consolidation grouting, percussion holes not less than 38 mm diameter shall be drilled.

Should the pressures not build up with the grout consistency first specified, the grout shall be gradually thickened up by adding cement and injection shall continue at a constant rate until the specified maximum pressures are achieved. If during this thickening process the pressures are built up rapidly, the grout consistency shall be thinned immediately and if necessary clear water shall be injected so as to avoid premature plugging.

The consistency of the grout mix shall be varied at any time to suit the response of the stage being injected.

Under no circumstances shall the pressure or rate of pumping be increased suddenly or the pressure in the hole being grouted exceed the maximum grouting pressure specified. In the event that rock is disturbed, remedial measures to repair the damage shall be determined and carried out by the Contractor.

The grouting of each stage shall be continued in accordance with the set procedures until the hole refuses to accept grout at the consistency and specified pressure.

After each stage of grouting is completed in any hole the back pressure shall be maintained by closing the inlet valve at the collar until the grout has set sufficiently, where after the hole shall be flushed, tested and re-grouted if necessary.

18.8.5 Jet grouting

18.8.5.1 Trial Sections

Prior to commencement of production jet grouting, a preliminary field trial section shall be constructed to verify the appropriate jet grouting system (Single, double or triple tube system) and the design grouting parameters. The trial section location shall be within the treatment area and the proposed location shall be agreed with the Engineer. It shall consist of a sufficient number of jet grouted columns arranged in a circle formation to facilitate excavation on the inside for visual assessment of the geometric, permeability and mechanical characteristics. The construction of the trial sections shall continue until the suitable parameters have been confirmed.

The acceptance testing shall also be calibrated during this trial operation. The testing shall be done prior to the confirmation excavation on the inside of the circular formation.

18.8.5.2 Acceptance Criteria

(a) Core Recovery

Refer to Clause 18.4.2.5. Minimum core recovery shall be 85%.

Since coring jet grouted soil may give misleading results about overall integrity, core recovery of 85% are not the sole criteria for acceptance.

Should the recovery be less than 85% this can also be supported by a borehole camera inspection, record of penetration rate and observations during the core drilling process. These should be considered and factored into the overall engineering judgment used for acceptance of geometric integrity.

(b) 28 Day Compressive Strength

The average 28-day unconfined compressive strength of the core samples taken from the matrix of any jet grouted column shall not be lower than 5 MPa. Not less than 3 samples shall be tested per test hole. Samples consisting only of rock shall be tested for compressive strength when considered necessary by the designer.

(c) Permeability

The average permeability of each core hole shall be determined by conducting a comprehensive Lugeon Test. The average Lugeon value shall not be greater than 1 (i.e. 1 Lugeon = 10^{-7} m/s).

(d) Seismic Methods

The integrity of the jet grouted columns shall be determined utilizing a Pile Integrity Test such as the "Tap Hammer Test" where a small metal or hard rubber hammer is used to produce a light tap on top of the pile. The shock waves travel down the length of pile and is reflected back from the toe of the pile (or any intermediate weakness or anomaly) and recorded through a suitable transducer/ accelerometer, which is also held on the top of the pile close to the point of impact.

18.9 CHECK HOLES

In order to check the effectiveness of grouting, the Contractor shall drill additional percussion or cored holes at any location, angle and depth within the range of the adjacent grout holes not less than 14 days after completing grouting in an area to enable water tests and possible supplementary grouting to be carried out. The number of holes required will be approximately 10% of the holes specified and shall be spread over the grouted area as agreed with the designer.

Check holes shall be grouted to the same requirements as the original holes.

18.10 RECORDS

The Contractor shall provide to the Engineer each day, an accurate record, in duplicate hard copy and electronically (spreadsheet format) of all drilling and grouting operations carried out the previous day.

The information provided shall include:

a) The location and reference number of the holes drilled and holes grouted;
b) The depth of concrete drilled, and total depth of hole drilled with measurements of any voids encountered;
c) Details of grout injections giving pressures, grout consistencies, volumes of grout injected, quantities of other material injected, and injecting times throughout the period of injection;
d) Charts from the recording pressure gauges and flow metres;
e) Results of mix control tests, times of sampling and location where samples were taken; and
f) Remarks on grouting incidents, delays, surface leaks, interconnections, refusals and any other factors which might influence the effectiveness of the grouting.

On completion of the grouting of a hole, within 24 hours, the Contractor shall provide the Engineer with a fresh and complete log, produced on a spreadsheet, printed in duplicate of the grouting work in that hole.

18.11 STEMMING OF HOLES

Upon completion of the grouting and checking of any area, the holes shall be washed using a flushing pipe to remove all loose materials and laitance from grout which has not hardened. The Contractor

shall then backfill all grout holes with a thick grout mix or dry pack mortar.

Filling of upward inclined holes shall be by pressure injection unless a thixotropic grout is used. Filling of downward inclined holes shall be through tremmie pipes pushed down to the bottom of the holes and withdrawn slowly as filling proceeds after first blowing all water out of the holes.

The end of each hole shall be filled to a depth equal to the lining thickness with dry pack mortar which is well rammed in and finished flush with the face of the concrete, or in the case of embedded sleeves, up to the end of the sleeve. If a box-out had been provided in the first stage concrete, if shall be filled with secondary concrete in accordance with Section 20 - Concrete Works (Structural).

If any hole shows signs of weeping water after being stemmed the hole shall be drilled out, re-grouted and re-stemmed.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 20

CONCRETE WORKS (STRUCTURAL)

TCTA MODULAR STANDARDS
SECTION 20
CONCRETE WORKS (STRUCTURAL)

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SECTION 20
CONCRETE WORKS (STRUCTURAL)

20.1 SCOPE

This Section deals with the use of plain, reinforced, pre-stressed and precast concrete in structural concrete works and provides amendments and additions to the South African National Standard SANS 2001, Part CC1: Concrete Works (Structural) which shall form part of the Contract. Clause headings followed by numeric characters refer to the sub-clause of the SANS 2001. Sub-clauses are numbered sequentially. The clause reference, to which a sub-clause refers, either amends or adds to the sub-clause in the SANS 2001. Where the sub-clause is an addition and there is no appropriate clause in the SANS 2001 to which it can be linked, no clause reference is given in the heading.

Should any requirement of this Section conflict with any requirement of the SANS 2001, Part CC1: Concrete Works (Structural), Section 20 shall prevail.

20.2 NORMATIVE REFERENCES

The applicable national and international standards as listed in Clause 2, Normative References of SANS 2001 CC1, shall apply to this Contract, with due cognisance of the provisions of Clause 1.14.1.

20.3 DEFINITIONS, ABBREVIATIONS AND REFERENCES

20.3.1 Definitions

(a) Specification Data (Sub-clause 3.1.11)

References to *Project Specification, Specification Data* and *Works Specification* shall mean references to this Section 20 - Concrete Works (Structural).

(b) Additives

Additives enhance the properties of concrete for a specific purpose. This could be setting time, viscosity, porosity, mechanical resistance, etc. There are generally nine types of additives: accelerators, retarders, plasticizers, flow promoters, air-entraining agents, anti-freezers, water-repellents and curing agents.

(c) Cementitious extenders

Portland cement extenders are cementitious materials used with ordinary portland cement and must not be used on their own. In the South African context these extenders are ground granulated blast furnace slag, fly ash and silica fume.

(d) Construction Joint

"Construction Joint" shall be a joint required on account of constraints or convenience in the method of construction and shall not be intended to be a movement, contraction or expansion joint.

(e) Designated Joints

"Designated Joints" means joints that are shown on the drawings consisting of movement, contraction or expansion joints.

Construction joints that are required by the Contractor as a result of his construction constraints or for any other reason, shall not be considered to be designated joints.

20.3.2 Abbreviations

BS: British Standard
CEM: Calcium-Enriched Mixture
CQC: Construction Quality Control
CSF: Condensed Silica Fume
FA: Fly Ash also known as Pulverised Fuel Ash (PFA)
GGBS: Ground Granulated Blast-Furnace Slag
GGCS: Ground Granulated Core Slag
HD: Holding Down
MPa: Megapascal
MQC: Manufacturing Quality Control
OPC: Ordinary Portland Cement
RHPC: Rapid-Hardening Portland Cement
RPM: Revolutions Per Minute
SANS: South African National Standard
SANAS: South African National Accreditation System
UFC: Ultra Fine Cement
UCS: Unconfined Compressive Strength

20.3.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014 and Construction Regulation 12.

20.4 REQUIREMENTS

20.4.1 General

20.4.1.1 Sprayed Concrete

Sprayed concrete is specified in Section 13 – Rock Support Materials.

20.4.1.2 Concrete Work Samples

At least 28 days before commencement of concrete work the Contractor shall supply full details and representative samples to the designer of the materials he intends using, together with certificates from SANAS accredited laboratories indicating that the materials comply with the requirements of this Section as well as the mix design for each type of concrete specified on the project. In the case of ready-mix equipment, equipment capacity and equipment calibration should be verified and the equipment will be inspected by the designer. All materials used for the concrete shall be from a consistent source.

No concrete shall be placed in the Works until the designer has approved the materials and the mix designs the Contractor intends using. For each mix design, the cube results as well as shrinkage test results must be included. Copies of the documents shall be provided to the Engineer.

After approval, these samples shall be taken as the standard for the agreed materials. If at any time during the course of the Contract there is a deviation from the approved standard or the source of material or if the Engineer considers that there has been a deviation, the Contractor shall submit further tested samples of the new materials to the designer for approval. Documentation to be included in the Contractor’s quality documentation

20.4.1.3 Brand Name Products

In addition to the requirements of this Section the requirements of manufacturers shall be strictly adhered to.

The Contractor shall confirm and submit to the Engineer at least 28 days prior to the commencement of any specific section of the Works, samples, specification and performance data, as applicable of all the products he intends to use.

20.4.1.4 Cementitious Binders (Clause 4.2.1)

(a) Cement Extenders

Cement extenders shall only be used where specified and approved by the designer. Cement extender shall only be blended with CEM I or CEM II Portland Cement.

(b) Conformity Criteria

The test results conducted to evaluate the conformity of cement in terms of SANS 50197-1, Clause 9, shall be made available to the designer and the Engineer before the materials are incorporated into the Works.

(c) Fly Ash Concrete

Where possible, cementitious material for fly ash concrete shall consist of a blend of CEM I or CEM II Portland Cement. The ratio of fly ash to cement may be varied by the designer before or during the Contract. Fly ash to comply with SANS 1491-2, Portland cement extenders- Part 2: Fly ash.

The fly ash and the Portland cement shall be added separately at the batching equipment where they shall be intimately mixed in the concrete mixer.

For structural concrete, the maximum total fly ash content by weight shall be 30%. For large mass concrete elements the maximum fly ash content by weight may be increased to 60% if approved by the designer.

20.4.1.5 Water (Clause 4.2.2)

Mixing water for concrete shall comply with the requirements of SANS 51008.

Untreated water from the river may not be used for mixing. It may possibly be used for curing but should be tested for confirmation. The use of water from the river sources shall be in compliance with legislative requirements of Department of Water and Sanitation – Water Use License.

20.4.1.6 Aggregates (Clause 4.2.3)

(a) General

All aggregate shall be of a consistent quality and from a consistent commercial source or borrow pit approved by the Engineer.

(b) Interpretation

The nominal stone size specified in the concrete class or grade is given by the figure after the oblique. For example, 30 MPa/40 mm shall mean stone conforming to the grading specified in SANS 1083 for the nearest equivalent size, i.e. 40 mm which means stone that complies with SANS 1083 for 37.5 mm size.

(c) Fine Aggregate

The fineness modulus sand delivered to the mixer shall lie between 1.7 and 3.0 and the standard deviation of fineness moduli of samples of sand that is delivered to the mixer shall be not more than 0.1 per aggregate batch.

(d) Use of Plums (Sub-clause 4.3.2.4 and 4.7.10.11)

The use of plums will not be permitted for structural elements, except where indicated by the designer for large mass concrete pours.

(e) Tests Required (Sub-clause 4.2.3.5)

The following minimum tests are required on concrete used in the Contract:

i) Drying shrinkage on fine and coarse aggregates;
ii) Drying shrinkage of concrete (maximum shrinkage 0.040%);
iii) Flakiness index of the stone; and
iv) Alkali-aggregate reaction (per SANS 6245:2006).

20.4.1.7 Admixtures, Air-entrainment Agents and Curing Agents (Clause 4.2.4)

Admixtures shall comply with SANS 50934 Parts 1 to 6 for admixtures (2011-2012). Admixtures are permitted, provided that the results of trial tests which demonstrate their suitability and the following are approved by the designer:

- The trade name of the admixture, its source and the manufacturer's recommended method of use;
- The chemical names of the main active ingredients in the admixture;
- Typical dosages and possible detrimental effects of under or over dosages;
- Whether compounds that are likely to cause corrosion of the reinforcement or deterioration of the concrete (such as those containing chloride, in any form, as an active ingredient) are present and, if so, the chloride content of the admixtures, expressed as a mass fraction of chloride ions or expressed as an equivalent mass fraction of anhydrous calcium chloride; and
- The average expected air content of the freshly mixed concrete containing an admixture that causes air to be entrained when the admixture is used at the manufacturer's recommended dosage.

20.4.1.8 Grade of Concrete (Clause 4.2.6)

(a) Classification

The grade of concrete shall be specified on the drawings and referenced in all quality documentation as follows:

A/B C (e.g. 30 MPa/19 mm F20)

Where

A = the 28-day characteristic strength (MPa)

B = the nominal maximum aggregate size e.g. 19 mm

C = the cement extender as a % of total cementitious material e.g.:

F20 = 20% of Fly Ash (FA)
C5 = 5% of Condensed Silica Fume (CSF)
G30 = 30% of Ground Granulated Blast-furnace Slag (GGBS)

20.4.1.9 Tendons (Clause 4.2.8)

(a) Characteristic Strength of the Steel (Sub-clause 4.2.8.2)

The characteristic strength of the steel shall not be less than 1860 MPa.

20.4.1.10 Joint Fillers, Sealants, Water Stops, Bearings and Accessories (Clause 4.2.11)

(a) Sealants (Sub-clause 4.2.11.1)

Moisture cured, high mechanical resistant polyurethane sealant shall be used for all watertight and water retaining structures including pump stations, valve chambers, and inlet and outlet structures.

Moisture cured, soft elastic polyurethane sealant shall be used for building structures above ground floor level.

Hydrophilic joint sealing systems shall not be used in movement, contraction or expansion joints.

In water retaining structures for potable water, the Contractor shall provide certification form the sealant supplier confirming that it is suitable for use in potable water.

(b) Water stops (Sub-clause 4.2.11.1)

Water stops shall be extruded plasticized PVC compound . and shall comply with the requirements of CKS 389:1973 having an elongation at break of 300%. Refer to subclause 20.4.5.1 for installation.

20.4.2 Formwork

20.4.2.1 General (Clause 4.3.1)

(a) Earth Cuts (Sub-clause 4.3.1.5)

Earth cuts may be used as forms for vertical surfaces only if dictated by the design and indicated on the drawings.

Concrete used in pipe trenches for encasement may be cast against the side of the excavation.

Concrete for thrust / anchor blocks shall be cast directly against the side of the excavation as shown on the drawings.

(b) Approval by Authority (Sub-clause 4.3.1.6)

Liaison with the authority controlling the service is required before commencing with the design of formwork over an existing service i.e. pipe lines, roads, streets, railways, etc. The design shall be submitted for approval by the authority.

(c) Surface Finish of Formed Surfaces (Sub-clause 4.3.1.8)

i) The formed surfaces of sections of the work shall be as specified in Sub-clause 4.3.1.8.
ii) The degree of accuracy for formed surfaces shall be Degree II (SANS 2001:CC1 Table 11).
iii) Special off-form surface finishes / exposed aggregate finishes shall be as shown on the drawings and, where they are required, listed in the Bill of Quantities.

(d) Chamfers and Fillets

All exposed external angles in concrete work shall have 20 mm x 20 mm chamfers unless otherwise specified by the designer and indicated on the drawings. Internal corners in concrete work need not have fillets unless such fillets have been indicated on the drawings.

20.4.2.2 Design and Construction of Formwork and Falsework (Clause 4.3.2)

20.4.2.3 Design of Formwork (Sub-clause 4.3.2.1.4)

Where approval is required in terms of Sub-clause 4.3.1.6, by a controlling authority, the design and drawings for formwork and falsework shall be submitted to the designer for review before being submitted to the authority for approval. Copies of the design and drawings and approval by the authority shall be submitted to the Engineer.

20.4.2.4 Formwork Accessories (Clause 4.3.3)

(a) Formwork Ties (Sub-clause 4.3.3.1)

All steel ties used for wall and other formwork shall run through a sleeve in order for the ties to be completely removed after the formwork has been struck. The sleeves shall be removed by drilling or any other appropriate method leaving a clean inner surface suitable for caulking / grouting.

The Contractor shall thoroughly caulk any tie holes left in the concrete and be accountable for the water tightness thereof. The details of the method and materials he intends using for caulking the tie holes shall be submitted to the designer for review and approval.

20.4.2.5 Removal of Formwork (Clause 4.3.8)

(a) Removal of Falsework and Supporting Formwork on Reinforced Concrete Structures (Sub-clause 4.3.8.3)

Where a continuously reinforced concrete structure will be constructed in stages, the Contractor shall submit to the designer for his review and approval, at least 28 days prior to the commencement of the work, full details of the manner in which the falsework and supporting frame work will be removed. Documentation and method statements to be included in the Contractor’s quality documentation

(b) Removal of Falsework and Supporting Formwork for Pre-stressed Concrete Structures (Sub-clause 4.3.8.4)

Where the falsework and supporting formwork in pre-stressed structures will be removed, prior to the full pre-stressing force relating to the particular stage of construction being applied, the Contractor shall submit to the designer for his review and approval, at least 28 days prior to the commencement of the work, full details of the manner in which the falsework and supporting frame work will be removed. Documentation and method statements to be included in the Contractor’s quality documentation

20.4.3 Reinforcement

20.4.3.1 Bending (Clause 4.4.1)

(a) Hot Bending (Sub-clause 4.4.1.3)

Bars shall not be bent hot.

(b) Stirrups

Stirrups for circular columns shall be individual circular bars. Spiral stirrups will not be permitted.

20.4.3.2 Fixing (Clause 4.4.2)

(a) Welding of Bars (Sub-clause 4.4.2.2 b)

Welding of bars will not be permitted.

(b) Spacers (Sub-clause 4.4.2.3)

Concrete spacer blocks manufactured on Site shall not be used. All spacer blocks shall be concrete, of the same strength as the structure. No plastic cover blocks will be allowed.

20.4.3.3 Cover (Clause 4.4.3)

(a) Exposure Conditions

The exposure conditions for the various structural members / surfaces are severe.

(b) Cover (Sub-clause 4.4.3.1)

The concrete cover over reinforcement shall be as given in Table 3, but shall not be less than 40 mm for any given class of concrete.

20.4.4 Holes, Chases and Fixing Blocks

20.4.4.1 Ferrules (Clause 4.5.3)

Refer to Clause 20.4.2.4.

20.4.5 Embedded Items

20.4.5.1 Water stops (Clause 4.6.2)

(a) General

Factory-made junction pieces shall be properly corner-mitred and jointed at intersections, shall be formed in accordance with the manufacturer's instructions and shall have a tensile strength across the joint of not less than 75% of that of the original material. Junction pieces shall be made so that all ribs in the original cross-section are maintained continuously and the joints are dense, homogeneous, free of all porosity and each leg of the junction having a minimum length of 300 mm. Intersections of waterstops with dissimilar pattern (i.e. "rearguard centre bulb" type, with "internal dumbbell" type) shall be made using specially-made junction pieces which accommodate the transition between patterns.

On site joints shall comply with the requirements for factory-made joints as specified above.

20.4.5.2 Pipes, Conduits and Ducts (Clause 4.6.3)

(a) Casting in of Pipes and Pipe Specials in Concrete

The Contractor shall be responsible for the installation, positioning, alignment and concreting in of all pipes and pipe specials regardless of whether or not these have been supplied by him.

Anchoring pipes or pipe specials into structures to resist longitudinal forces, shall be avoided if possible, however if it is dictated by design, specially designed anchor flanges shall be provided., Reinforcement shall be added around the anchor flanges to tie in with protruding reinforcement before the pipe or pipe special is concreted in.

Reinforcement around pipes to be cast in or in box-outs for pipes shall be detailed such as to allow sufficient space for installation without contact or damage to pipe coating.

No wet-to-dry epoxy (bonding compound) will be allowed for grouting of box-outs.

20.4.6 Quality of Concrete

20.4.6.1 General (Clause 4.7.1)

The cementitious content of a binder for any class of concrete shall not exceed 450 kg/m^3 of concrete.

20.4.6.2 Consistency (Clause 4.7.2)

(a) Slump (Sub-clause 4.7.2.1)

The minimum slump for vibrated concrete shall be 50mm and the maximum slump shall be 100 mm. For pumped mixes the maximum slump can be increased to 125 mm. If a low slump mix is used for the large mass concrete structures, consistency will be measured using VeBe testing as described in Clause 20.5.1.1.

Hand-compacted concrete will not be permitted.

20.4.6.3 Workability (Clause 4.7.3)

(a) Pumping of Concrete (Sub-clause 4.7.3.2 and 4.7.10.15)

Pumping of concrete will be permitted.

20.4.6.4 Chloride and Sulphate Content (Clause 4.7.4)

(a) Chloride Content (Sub-clause 4.7.4.1)

The maximum chloride ion content for mass concrete shall be as given in Table 5; and for reinforced concrete shall be 0.2%

Efflorescence will not be acceptable on any exposed concrete surface.

(b) Sulphate Content (Sub-clause 4.7.4.2)

The total water soluble sulphate content of a concrete mix shall not exceed a mass fraction of 4% of the cementitious binder content of the mix.

20.4.6.5 Prescribed-mix Concrete (Clause 4.7.6)

(a) Water Retaining Structures (Sub-clause 4.7.6.1)

Any mix to be used in the wall, floor or roof of a water retaining - or excluding structure shall have a water / binder ratio not exceeding 0.53, shall have a cementitious content of not less than 325 kg/m^3 of concrete and the proportions of the various aggregates shall be such as to produce a density of at least 2 400 kg/m^3. The cementitious material shall consist of a blend of CEM I or CEM II Portland Cement with a maximum total fly ash content by weight of 30%. The ratio of fly ash to cement may be varied by the designer before or during the Contract.

20.4.6.6 Mixing (Clause 4.7.8)

All concrete for structural elements and including the large mass concrete pours shall be produced at an accredited batching equipment, commercially or on site and shall be mixed in accordance with SANS 878. Hand mixing or small volume on-site batching will not be permitted for these elements.

20.4.6.7 Placing (Clause 4.7.10)

(a) Under Water (Sub-clause 4.7.10.13)

Concrete may be placed under water if dictated by the design and indicated on the drawings. A mix design for this concrete shall be submitted for approval by the designer.

(b) Placing of Large Mass Concrete Sections

Placing of concrete for large mass concrete structures shall be such that vertical joints are avoided, except where dictated by design. Plate vibrators may be used on these sections, supplemented by poker vibrators.

The concrete shall be placed continuously as far as possible. Already-placed horizontal surfaces or 'joints' shall be kept "live" over the period until the placing of the next horizontal lift using continuous light fog spray, i.e. the surface is to be kept moist, not flooded. For interruptions of more than 24 hours, the surface shall still be kept moist, but additional treatment of the surface may be required such as hydro-jetting or brooming, if approved of the designer. No wet-to-dry epoxy (bonding compounds) may be used.

Maximum lift height cast per day is 1000 mm.

20.4.6.8 Compaction (Clause 4.7.11)

(a) Method (Sub-clause 4.7.11.3)

Compaction shall only be achieved by means of mechanical vibration.

20.4.6.9 Joints (Clause 4.7.12)

(a) Construction Joints

(i) Location (Sub-clause 4.7.12.1.1)

Construction joints will be required.

The location and details of planned construction joints, not indicated on the drawings, shall be submitted to the designer for review and approval.

(ii) Proprietary Bonding Compounds (Sub-clause 4.7.12.1.2)

No proprietary bonding compounds may be used between old and new concrete.

(b) Sealing of Joints (Sub-clause 4.7.12.4)

The sealing of joints shall be undertaken in accordance with the requirements of the details as shown on the drawings. In addition to the requirements of this Section the requirements of the manufacturers of products shall be strictly adhered to.

20.4.6.10 Curing and Protection (Clause 4.7.13)

(a) Curing Compound (Sub-clause 4.7.13.2.e)

Curing through ponding (horizontal surfaces) is preferred where possible.

The use of membrane curing compounds will be considered on vertical surfaces or inclined surfaces of cast in situ members of a structure. Contractor to provide details to the designer for approval. Documentation and method statements to be included in the Contractor's quality documentation

Wax based curing compounds, plastic sheets or intermittent spray / sprinkle as method of curing will not be permitted.

The curing compound shall be applied immediately as formwork is progressively stripped or, in the case of unformed surfaces, when the concrete has taken its initial set. The compound shall preferably be applied by spraying and the rate of application shall be strictly in accordance with manufacturer's recommendations. A method of monitoring the area to which the curing compound has been applied, and the application rate, shall be approved by the designer and rigidly adhered to by the Contractor.

Surfaces of joint rebates, where elastomeric sealant is to be applied, shall be protected from contamination by curing compound.

20.4.6.11 Adverse Weather Conditions (Clause 4.7.14)

(a) Prevention and Repair of Plastic Shrinkage Cracks

The Contractor shall take whatever measures are necessary to prevent plastic shrinkage cracking in the concrete. Particularly on dry windy days or hot sunny days the Contractor shall make provision for fine spraying of the concrete surface within one hour of casting, or immediately covering the concrete with white plastic sheeting. Erection of wind breaks may also be required.

Repair of plastic shrinkage cracks that occur after floating of the concrete shall be as per the Contractor's quality documentation. Curing shall commence as soon as possible after repair.

(b) Ambient Temperatures and Heat of Hydration

The Contractor shall take cognizance of possible high ambient temperatures as well as possible large cross-sectional areas in some of the structures and shall consider mitigating measures in terms of mixing and placing of concrete to accommodate high ambient temperatures as well as heat of hydration of the concrete sections. The mitigation shall be submitted in a method statement for approval by the designer. Documentation and method statements to be included in the Contractor's quality documentation

The maximum casting temperature of the concrete for structural elements, and large mass concrete pours shall be a target of 25 degrees C with a maximum of 30 degrees C unless otherwise specified by the designer. The temperature shall be measured and recorded for every truck at point of placement. Measurement of insitu concrete temperatures may be required for large pours.

20.4.6.12 Concrete Surfaces (Clause 4.7.15)

(a) Exposed Surfaces (Sub-clause 4.7.15.1)

If a dry, low slump mix is used for large mass concrete sections, additional measures shall be applied to render a smooth, durable surface finish. The proposed method shall be included in the Contractors quality documentation for approval by the designer.

(b) Screeded Finish (Sub-clause 4.7.15.1 a)

No mortar shall be added during the screeding operation, and noticeable surface irregularities caused by the displacement of coarse aggregate shall be made good.

(c) Wood-floated Finish (Sub-clause 4.7.15.1 b)

Where wood-floating is specified, the surface shall first be given a finish as specified in Sub-clause 4.7.15.1 (a) and, after the concrete has hardened sufficiently, the surface shall be wood-floated, either by hand or machine, only sufficiently to produce a uniform surface free from screeding marks.

(d) Steel-floated Finish (Sub-clause 4.7.15.1 c)

Where steel-floating is specified, the surface shall first be given a finish as specified in Sub-clause 4.7.15.1 (b). When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the screeded surface shall be

finished through a combination of wood-floating, followed by steel floating under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

(e) Power Float Finish

Where power floating is specified, the surface shall be treated as specified in Sub-clause 4.7.15.1 (a). When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the surface shall be power floated to produce a dense, smooth and uniform surface free of trowel marks. In corners and areas of restricted access the concrete surface shall be finished by steel floating or as indicated on the drawings.

(f) Broom-swept Finish (Sub-clause 4.7.15.2)

Where broom-swept finish is specified, the surface shall be wood floated as specified in Sub-clause 4.7.15.1 (b) and thereafter swept with a stiff bristle broom to produce a non-skid surface.

(g) Colour Mitigation – Application

Surfaces to be coloured shall be free of curing compounds or other material that may prevent direct contact with the colouring.

The colouring shall be applied per supplier's specifications. Dark patches that may develop shall be controlled or avoided.

Rock colouring material shall be applied only by licensed applicators approved by the manufacturer.

(h) Concrete Topping (screed)

Minimum screed thickness to be 30mm.

Preparation of base concrete prior to screed or topping application shall be included in the Contractor's quality documentation or as indicated on the drawings. No wet-to dry epoxy (bonding compound) will be permitted.

Topping (screed) shall be compacted to remove all air and shall be screeded and steel trowel finished to a degree of accuracy II or as indicated on the drawings.

Toppings shall be cured as specified but shall additionally be protected from direct sunlight and drying winds as it is being placed.

All screeding necessary to accommodate mechanical equipment shall be done under the equipment supplier's supervision and strictly in accordance with his requirements.

20.4.6.13 Watertight Concrete (Clause 4.7.16)

The following structures shall be regarded as watertight structures:

i) Pumping stations;
ii) Diversion works;
iii) Valve chambers;
iv) Inlet and outlet Works;
v) Reservoirs;
vi) Protective capping layer on weir crest (if applicable); and
vii) Other as specified on the drawings.

The tests in Sub-clause 5.1.6.1 not be required for pump stations and valve chambers, unless specified by the designer.

However, should any section of the concrete Works show any sign of water leakage or penetration, irrespective of the source, that section shall be deemed to be defective and the necessary remedial work shall be carried out in accordance with Sub-clause 5.1.6.3. or as per designer's specifications. Documentation and method statements to be included in the Contractor's quality documentation

20.4.6.14 Grouting (Clause 4.7.18)

(a) Holding-down Bolts, Column Bases and Mechanical Equipment Bedplates

The mortar grout for holding-down bolts, column bases and mechanical equipment bedplates shall be a proprietary grout ready mixed in sealed packets as supplied by the manufacturer, and mixed and placed in accordance with the manufacturer's requirements.

20.4.6.15 Defects (Clause 4.7.19)

(a) General

Defects shall be repaired as soon as possible after formwork has been removed and the post-concrete inspection has been completed per the Contractor's quality documentation. Repair of structural concrete shall be in accordance with the specification of the proprietary repair material supplier and Contractor's quality documents, approved by the designer prior to commencement of repairs. Repair of localised defects shall include the following:

i) Areas to be clearly demarcated by the designer or the Engineer
ii) Repair area to be rectangular

iii) Saw-cut area to 10mm depth, without damaging rebar, rendering straight edges. Saw-cuts to be perpendicular to concrete surface, i.e. no feather edging.
iv) Remove damaged / defective concrete to at least 15mm beyond rebar
v) Material application and curing per proprietary material supplier's specifications

The Engineer may prohibit the further placing of concrete in the particular structure concerned until he is satisfied that the repair has been satisfactorily executed.

20.4.6.16 Units that have Architectural Finishes (Clause 4.8.6)

(a) Samples of Concrete (Sub-clause 4.8.6.1)

Samples of precast concrete units that have architectural finishes shall be prepared for approval by the designer prior to construction. The approved samples shall be retained throughout the contract as reference.

Samples of concrete units, not having architectural finishes shall also be prepared to establish quality before full-scale production is commenced.

20.4.7 Pre-stressed Concrete

20.4.7.1 Tendons (Clause 4.9.2)

(a) Solvents (Sub-clause 4.9.2.1.1)

Solvents may be used for cleaning.

(b) Pre-stressing Force Diagram (Sub-clause 4.9.2.5.1)

Pre-stressing force diagrams will be shown on the drawings.

(c) Order of Loading and Magnitude (Sub-clause 4.9.2.5.8)

The order of loading and magnitude of the load for each component of the tendon shall be indicated on the drawings.

20.4.7.2 Grouting of Sheaths (Clause 4.9.3)

(a) Tests (Sub-clause 4.9.3.1.2)

Bleeding tests and grouting trials will be required.

20.4.7.3 Permanent Protection and Bonding of External Tendons (Clause 4.9.4)

(a) Tests (Sub-clause 4.9.4.2)

Preliminary tests shall be undertaken on the proposed encasement materials.

(b) Protection (Sub-clause 4.9.4.3)

The protection and bonding of the tendons shall be effected within 7 days after final tensioning of the tendon(s).

20.4.8 Handling and Erection of Precast Concrete Units

20.4.8.1 Handling and Transportation (Clause 4.10.1)

(a) Lifting (Sub-clause 4.10.1.3)

The position of lifting and supporting points, the method of lifting, the type of equipment and the type of transport to be used shall be determined by the Contractor in liaison with the designer. Lifting positions shall be indicated on the drawings. For precast lids or precast elements that may require future removal for repair of maintenance purposes, the weight of each element shall be indicated on the drawings.

20.4.8.2 Assembly and Erection (Clause 4.10.2)

(a) Methodology (Sub-clause 4.10.2)

At least 28 days before commencement of the work, the Contractor shall submit a Method Statement including proposed methods of assembly and erection for review by the Engineer.

20.4.8.3 Forming Structural Connections (Clause 4.10.4)

(a) Design (Sub-clause 4.10.4.1)

The design requirements for the structural connections will be indicated on the drawings.

20.5 COMPLIANCE WITH THE REQUIREMENTS

20.5.1 Testing

20.5.1.1 General (Clause 5.1.1)

(a) Slump testing (Sub-clause 5.1.1.2)

If the concrete mix design is such that slump tests may not be feasible (e.g. dry mixes for large mass concrete structures), VeBe testing in accordance with SANS 5862-3:2006 may be required

to determine consistency with recommended VeBe time of 10 +/- 3 seconds. Documentation and method statements to be included in the Contractor's quality documentation and to be approved by designer.

(b) Cube testing (Sub-clause 5.1.1.4)

For the large mass concrete pours with low compressive strength, the designer may specify cubes be tested for acceptance at 56 days after placing or as indicated in the Contractor's quality documentation, depending on the proposed concrete mix design. Intermediate cube control testing will be required at intervals proposed by the Contractor. These earlier-age test results can be calibrated with the 56-day test results, and used for mix control at earlier ages.

(c) Ready-mix Production (Sub-clause 5.1.1.7)

The tests results from a ready-mix production facility, that form part of its quality control system, will not be accepted as valid test data.

(d) Alkali-aggregate Reaction (Sub-clause 5.1.1.8)

The test for the percentage of alkali-aggregate shall be Petrography ASTM C 295 and Accelerated Mortar-bar test SANS 6245:2006.

20.5.1.2 Acceptance of Strength Concrete (Clause 5.1.2)

(a) Assessment (Sub-clause 5.1.2.3)

The test results will be assessed statistically.

20.5.1.3 Frequency of Sampling (Clause 5.1.3)

The frequency of sampling shall be indicated in the Contractor's quality control documentation.

20.5.1.4 Individual Load Tests on Precast Units and Pre-stressed Units (Clause 5.1.4)

The following load test values will be as indicated on the drawings:

(a) Deflection (Sub-clause 5.1.4.2.1)

The maximum deflection.

(b) Load (Sub-clause 5.1.4.3)

The ultimate design load.

(c) Special Tests (Sub-clause 5.1.4.4)

Any special tests required.

20.5.1.5 Tests on Pre-stressed Structures (Clause 5.1.5)

(a) Tests Requirements (Sub-clause 5.1.5.1.1)

Particular requirements for pre-stressed structures will be indicated on the drawings.

(b) Acceptance Criteria (Sub-clause 5.1.5.4 and Table 10)

The acceptance criteria for pre-stressed structures in extreme exposure conditions will be indicated on the drawings.

(c) Class (Sub-clause 5.1.5.4 a)

The class of pre-stressed structure shall be indicated on the Contractor's drawings.

(d) Deflection (Sub-clause 5.1.5.4 c)

The deflection measured immediately after application of the test load for deflection shall not exceed the values indicated on the drawings.

20.5.1.6 Tests for Water tightness (Clause 5.1.6)

(a) Requirements (Sub-clause 5.1.6.1)

Water shall be used as the liquid for test purposes.

The stabilizing period is 7 days for a maximum design crack width of 0.1 mm and 21 days for a maximum design crack width of 0.2 mm.

The total permissible drop in level is 10 mm or 1/500th of the average water depth, whichever is the lesser value.

For structures retaining potable water such as reservoirs, disinfection will be required prior to testing. Disinfection method to be included in the Contractor's quality documentation and approved by the designer.

20.5.2 Tolerances

20.5.2.1 General (Clause 5.2.1)

(a) Degree of Accuracy (Sub-clause 5.2.1.1)

The degree of accuracy is II unless otherwise specified by the designer and indicated on the drawings.

(b) Floated Finishes (Sub-clause 5.2.1.2)

The degree of accuracy for floated finishes is II unless otherwise specified by the designer and indicated on the drawings.

(c) Tolerances not stated (Table 11)

The tolerances not included in Table 11 shall be indicated on the drawings.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 21

GABIONS AND RENO MATTRESS STRUCTURES

TCTA MODULAR STANDARDS
SECTION 21
GABIONS AND RENO MATTRESS STRUCTURES

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SECTION 21
GABIONS AND RENO MATTRESS STRUCTURES

21.1 SCOPE

This Section covers the use of gabion cages and Reno mattresses for the construction of retaining walls, aprons, channel linings and other erosion protection measures.

21.2 DEFINITIONS

21.2.1 Definitions

The following terms shall have the meanings given:

a) **"Gabion"** a steel wire mesh basket or cage, usually rectangular, packed with rocks.
b) **"Reno mattress"** a steel wire mesh container in the shape of a mattress, filled with rocks.
c) **"Stone"** rock fragments obtained through a mechanical crushing process or naturally occurring boulders.
d) **"Rock fragments"** individual particles together constituting the stone.
e) **"Steel wire mesh"** a woven or welded barrier manufactured from connected steel wires with a regular pattern.
f) **"Geotextile"** a synthetic-fibre filter fabric used for separation, filtration and drainage.

21.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with the OHSAct 85 of 1993, Construction Regulation 2014, Construction Regulation 28 – Stacking.

21.3 MATERIALS

21.3.1 General

Generally gabions shall be flexible, galvanised steel wire mesh cages packed with durable stone.

The use of all materials and proposed proprietary systems shall be subject to the prior approval of the designer.

21.3.2 Stone

21.3.2.1 Quality

Stone used as filling for the gabions and Reno mattresses shall be clean, hard, durable, un-weathered boulders or rock fragments, free from fissures and flaking and shall be of such a shape that a stable protection structure of the required thickness is formed.

Rounded boulders or cobbles shall not be used. Stone shall have a relative density of at least 2.65 and:

a) When the stone is subjected to the weathering test given in Clause 21.6.3, the loss of mass shall not exceed 5%; and

b) In the case of dolerites, when the stone is subjected to the durability test given in Clause 21.6.4, the number of stones broken near their middle shall not exceed 5% of the total.

21.3.2.2 Size

No rock fragment shall be of such a size that it will pass through a ring of diameter 10% greater than the cross-dimension of the mesh being used for the gabion (dimension *B* in Table 21/1).

No rock fragment shall be of a size exceeding the maximum size given in column 4 of Table 21/1, and at least 85% of the rock fragments shall be of a size equal to or exceeding the minimum size given in column 3, appropriate (in each case) to the nominal depth of the gabion and, when relevant, to the nominal mesh size.

TABLE 21/1
SIZE OF STONE FRAGMENTS FOR GABIONS

1	2	3	4
NOMINAL DEPTH OF GABION CAGE m	**NOMINAL SIZE OF MESH (NOMINAL CROSS-DIMENSION *B*)** mm	**FRAGMENT SIZE (LARGEST DIMENSION)** mm	
		Min.	**Max.**
0.2	60	100	120
0.3	60	100	150
0.5	80	100	200
1.0	80	100	250

21.3.3 Wire

a) All wire used to manufacture the cages (gabions and Reno mattresses) shall comply with the requirements of SANS 675 for mild steel wire and shall have a tensile strength of not

less than 350 MPa. Wire shall be zinc coated as per SANS 675 for Class A heavy duty galvanised mild steel wire.

TABLE 21/2
STANDARD MESH-WIRE

MESH TYPE		B*	TOLERANCE (MM)	OD WIRE Ø (MM)
60	Galvanised	60	-4 + 10	2,2
	Galvanised + PVC	60	-4 + 10	2,2 / 3,2
80	Galvanised	80	-4 + 10	2,7
	Galvanised + PVC	80	-4 + 10	2,7 / 3,7
* B is the mesh opening, the distance between the axis of two consecutive twists according to SANS 1580: 2005				

TABLE 21/3
PROPERTIES OF WIRE

MESH TYPE	USE	UNITS	LACING	MESH	SELVEDGE
60	Wire** Galvanised Galvanised + PVC	Ø mm	2.2 2.2 / 3.2	2.2 2.2 / 3.2	2.7 2.7 / 3.7
	Wire Tolerance*	Ø mm	± 0.08	± 0.08	± 0.08
	Quality of zinc*	g/m^2	245	245	275
	Tensile strength*	N/mm^2	350-575		
80	Wire** Galvanised Galvanised + PVC	Ø mm	2.2 2.2 / 3.2	2.7 2.7 / 3.7	3.4 3.4 / 4.4
	Wire Tolerance*	Ø mm	± 0.08	± 0.08	± 0.1
	Quality of zinc*	g/m^2	245	275	275
	Tensile strength*	N/mm^2	350-575		
* According to SANS 675:1997 ** According to SANS 1580:2005 and SANS 675:1997					

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns round a mandrel of four times the diameter of the wire, it shall not flake or crack to such an extent that any zinc can be removed by rubbing with bare fingers.

b) Wire mesh shall be double twisted hexagonally woven, of the types specified, complying with the requirements of SANS 1580: 2005.

21.3.4 Synthetic-fibre Filter Fabric (Geotextile)

Geotextile shall be Grade 2 as specified in Section 27 - Drainage and Erosion Protection.

21.3.5 Concrete

Concrete shall comply with Section 20 - Concrete Works (Structural).

21.4 CONSTRUCTION

21.4.1 General

Cages shall be fabricated of galvanised wire mesh, double twisted hexagonally woven to the mesh types and selvedge as specified above and in Tables 21/2 and 21/3. The cages shall be subdivided into cells by wire mesh diaphragms, manufactured from double twisted galvanised wire, hexagonally woven to the mesh types specified overleaf:

Gabions

Length:	1, 2, 3 and 4 m
Width:	0.5 m, 1 m and 1.5 m
Depth:	0.5 m and 1.0 m
Mesh Type:	80
Diaphragm spacing:	1 m
Diaphragm Mesh Type:	80

Reno Mattresses

Length:	2.3 and 6 m
Width:	1 m and 2.0 m
Depth:	0.3 m
Mesh Type:	60
Diaphragm spacing:	600 mm
Diaphragm Mesh Type:	60

21.4.2 Selvedges

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedged with wire, as specified in Tables 21/2 and 21/3, complying with SANS 675. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it must be attached by binding the cut ends of the mesh about it so that a force of not less than 8.5 kN applied in the same plane as the mesh, at a point on the selvedge of a mesh sample 1 m long, is required to separate it from the mesh.

21.4.3 Diaphragms and E-panels

The diaphragms and end panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by twisting the cut ends of the mesh wires at the bottom of the panel about the selvedge on the base of the gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joints of the mesh at the base of the gabion. In each case the force required to separate the panels from the base should not be less than that required to break the mesh over the same length.

21.4.4 Binding and Connecting Wire

Sufficient binding and connecting wire shall be supplied with the gabions to perform all the tying and lacing operations to be carried out in the construction of the gabion work. The diameter of the wire shall be as specified in Table 21/3.

21.4.5 Tolerances

The tolerance on the specified diameter of all wire and on the mesh openings shall be as specified in Tables 21/2 and 21/3. The length of the cages shall be subject to a tolerance of ± 5%, the width of the cages shall be subject to a tolerance of ± 3% and the depth of the cages shall be subject to a tolerance of ± 5%.

21.4.6 Preparation of the Foundation and Surface for Bedding

The surface on which the gabion or Reno mattress cages are to be laid prior to them being filled with rock shall be levelled to the depth shown on the drawings or as directed by the Engineer to present an even surface. Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the drawings or indicated by the designer.

21.4.7 Synthetic-fibre Filter Fabric (Geotextile)

One layer of geotextile as specified in Clause 21.3.4 shall be placed where indicated on the drawings or directed by the Engineer. The fabric shall be placed and secured flush against the base and the sides of the excavation prior to the placement of the gabions or Reno mattresses, in accordance with the instructions, in strips with a minimum overlap of 300 mm at the joints and properly secured to prevent any movement or slipping during installation of the rock fragments.

21.4.8 Construction of Cages

21.4.8.1 Assembly, Erection and Stretching

(a) Assembly

Prior to assembly, the gabion material shall be opened out flat on the ground and stretched to remove any kinks and bends. The gabion cages shall then be assembled individually by raising the sides,

ends and diaphragms ensuring that all creases are in the correct position and that the tops of all four sides are even. The four corners of the gabion cages shall be laced first followed by the edges of internal diaphragms to the sides. In all cases lacing shall commence at the top of the box by twisting the end of the lacing wire around the selvedges. It shall then be passed round two edges being joined, through each mesh in turn and securely tied off at the bottom. The ends of all lacing wire shall be turned to the inside of the box on completion of each lacing operation.

(b) Erection

Only assembled boxes or groups of boxes shall be positioned in the structure. The side, or end, from which work is to proceed, shall be secured to either completed work or by rods or stakes driven into the ground at the corners. These must be secured and reach at least to the top of the gabion box. Further gabions shall then be positioned in the structure as required, each being securely laced to the preceding one at all corners and diaphragm joints.

(c) Stretching

On completion of erection of a suitable length of gabion, the gabion cages shall be stretched using a wire strainer or winch of at least one ton capacity firmly secured to the free end of the assembled gabion cages.

Whilst under tension, the gabion cages shall be securely laced along edges (top, bottom and sides) and at a diaphragm point, to all adjacent boxes and shall thereafter be filled.

21.4.8.2 Rock Filling

(a) Cages in Retaining Walls

Particular care shall be taken in packing the visible faces of gabion cages, where only selected rock fragments of the specified size shall be used so as to obtain an even faced finish. The cages shall be filled in layers to prevent deformation and bulging. Cages shall be filled to just below the level of the wire braces, after which the braces shall be twisted to provide tension. Care must be taken to ensure that the consecutive layers in cages are filled evenly to a level surface ready to receive the next layer.

(b) Mattresses used in Revetments and Aprons

The 0.3 m deep Reno mattresses forming aprons and revetments shall be filled by random rock fragments being packed in the first layer and by selected rock fragments being used for the top layer so as to resemble normal stone pitching.

(c) General

Filling shall be carried out only whilst gabion cages and Reno mattresses are under tension. Filling material shall consists of rock fragments of sizes as specified in Clause 21.3.3.2 so placed to produce a neat face and line with a minimum of voids.

Internal horizontal bracing wire shall be provided at 500 mm vertical centres or such spacing as to ensure a ratio of four wires to every 1 m^2 of filling. These bracing wires shall be wrapped around two mesh wires and extended from front to back and so positioned to ensure a neat face and line free of excessive bulges and depressions. Gabion cages shall be filled in layers and horizontal bracing wires inserted as filling is brought up.

Similar bracing wires used vertically shall be provided in 0.5 mm deep gabions at 330 mm horizontal centres where waterfalls directly onto gabions or where a neat face is required.

Tension on the gabion cages shall be released only when sufficiently full to prevent the mesh from slackening. Gabion cages shall be overfilled by 20 to 50 mm above their tops to allow for subsequent settlement of the rock fragments.

21.4.8.3 Grouted Rock Fill

Grouted rock fill, if required shall be done in accordance with Section 27.

21.4.8.4 Final Wiring

Closing and wiring down of lids shall proceed as soon as possible after filling operations and certainly in the likelihood of storms or floods occurring during construction. The wiring down shall consist of wrapping around wire at such intervals as required or specified.

Lids shall be stretched tight over the filling with bars and wired down securely through each mesh along all edges, ends and diaphragms. The ends of all tying and bracing wires shall be turned into the gabion box on completion of all lacing operations. Tightness of mesh, well packed filling and secure lacing is essential in all structures.

21.5 TRIMMING AND CLEARING UP ON COMPLETION

After completion of construction, all areas affected by the Contractor's operations shall be cleaned up and finished off and all rock larger than 75 mm maximum dimension, shall be removed and disposed of in approved spoil areas.

All intersecting earthwork slopes shall be neatly rounded. Drains shall be cleared of debris and obstructions, and any excess earth, debris or other waste material shall be removed to spoil or shaped and trimmed as directed by the designer.

All loose stones, dead vegetation or other waste matter exposed on fill or excavation slopes which are liable to become loosened and fall into drains shall be removed.

All parts of the work and adjacent ground shall be left in a neat and presentable condition to the satisfaction of the Engineer.

The rehabilitation of all disturbed areas shall be in accordance with Section 47 – Landscaping and Rehabilitation.

21.6 TESTS

21.6.1 Taking and Testing of Samples

The Contractor shall carry out sufficient tests to ensure the consistency of materials used for and placed in gabion cages and used for pitching.

21.6.2 Material or Standard of Finish not to Specification

The Engineer may carry out such additional check tests as he deems necessary, at any depth or on any layer. Where these tests reveal that the material used does not comply with the applicable requirements of the specification, or that the specified standard of finish has not been attained, the Contractor shall rectify the work.

21.6.3 Weathering Test

A crushed sample taken from the stone to be used shall be tested as follows:

a) At least 500 g of stone passing through a square mesh sieve of nominal aperture size 19 mm and retained on a square mesh sieve of nominal aperture size 13.2 mm shall be dried to constant mass (*M1*) in an oven that is maintained at 105 ºC ± 2 ºC.

b) The dried stone shall be immersed in a saturated Glauber salt solution in a porcelain dish for 8 hours, after which it shall be carefully separated from the solution by decantation and placed in the oven (see (a) above) for 14 hours.

c) The stone shall then be allowed to cool at room temperature for 2 hours.

d) The procedure given in (b) and (c) above shall be repeated for a total of 10 cycles, after which the stone shall be thoroughly washed with hot water, dried to constant mass as in (a) above, screened on a square mesh sieve of nominal aperture size 1.70 mm, and the material retained on this sieve shall be weighed (*M2*). The percentage weathering loss calculated from the formula $(100(M1 - M2))/M1$ shall not exceed 5%.

21.6.4 Durability Test

In addition to being tested in accordance with Clause 21.6.3, stones from doleritic source material shall be subjected to a durability test as follows:

a) From a crushed sample taken from the stones to be used, 100 stones passing through a sieve of nominal aperture size 53.0 mm and retained on a sieve of nominal aperture size 26.5 mm shall be taken at random.
b) The stones shall be washed to remove all adhering material.
c) The stones shall then be dried for 4 hours in a well-ventilated oven maintained at 105 ºC ± 5 ºC and, after they have cooled to room temperature, they shall be weighed.
d) The procedure given in (c) above shall be repeated until the decrease in mass after each of two successive drying periods of 4 hours does not exceed 0.1% of the total mass.
e) The 100 dried stones shall then be placed in a suitable container and covered with ethylene glycol maintained at a temperature of 18 ºC to 25 ºC, for 20 days.

The number of stones that have broken near the middle shall be determined and this number shall not exceed 5.

21.6.5 Gabion Cages after Installation, Filling and Lacing

The lacing of the edges of adjoining cages, of diaphragms to side panels, and of lids (after filling of the gabion cage) shall be tested by the application, of a tensile force in the relevant plane and the force required to separate the edges, the diaphragms and the lids shall, in each case, be at least 1.5 kN/m.

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SECTION 24
STRUCTURAL STEEL

24.1 SCOPE

This Section deals with structural steelwork for buildings and other structures as specified.

This Section provides amendments and additions to the South African National Standard SANS 2001, Part CS1: Structural Steelwork which shall form part of the Contract.

Clause headings followed by numeric characters refer to the sub-clause of the SANS 2001. Sub-clauses are numbered sequentially. The clause reference, to which a sub-clause refers, either amends or adds to the sub-clause in the SANS 2001. Where the sub-clause is an addition and there is no appropriate clause in the SANS 2001 to which it can be linked, no clause reference is given in the heading.

Should any requirement of this Section conflict with any requirement of the SANS 2001, Part CS1: Structural Steelwork, this this Section shall prevail.

24.2 NORMATIVE REFERENCES

The applicable national and international standards as listed under Clause 2, Normative References of SANS 2001-CS1 shall apply, with due cognisance of the provisions of Clause 1.14.1.

24.3 ABBREVIATIONS AND REFERENCES

24.3.1 Abbreviations

ANSI: American National Standards Institute
ASTM: American Standard for Testing Material
AWS: American Welding Society
BS: British Standard
CQC: Construction Quality Control
EN: European Norm
MPa: Megapascal
MQC: Manufacturing Quality Control
PDF: Portable Document Format
SANS: South African National Standard
SANAS: South African National Accreditation System
UNS: Unified Numbering System

24.3.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHS Act 85 of 1993, Construction Regulation 2014, Construction Regulation 12 - Temporary works, Construction Regulation 25 - Use of flammable liquids, Construction Regulation 10 - Fall protection, General Safety Regulation 9 - Welding, General Safety Regulation 13A - Access ladders.

24.4 REQUIREMENTS

24.4.1 Materials

24.4.1.1 Structural Steel (Clause 4.1.1)

(a) Hot-rolled Sections

The grade of steel used for the fabrication of structural steel work consisting of hot-rolled sections, shall be Grade 350WA and shall comply with EN 10025-2 as the governing standard. Grade 350WA shall be considered equivalent to Grade S355JR.

(b) Hollow Sections

Structural hollow sections shall comply with the requirements of SANS 657: Part 1 and have a minimum yield strength of 300 MPa.

(c) Cold-formed Sections

Open cold-formed sections shall be rolled from commercial grade steel and comply with the requirements of SANS 10162: Part 2. The minimum design yield strength shall be 225 MPa.

(d) 3CR12

Where specified, 3CR12 shall comply with the requirements of ASTM A240 (UNS S41003), EN 10088-2 (1.4003) and EN 10028-7 (1.4003).

(e) 304 and 316 Stainless Steel

Where specified, stainless steel 304 and 316 shall comply with the requirements of ASTM A240 (UNS S30400) and (UNS S31600) respectively.

24.4.1.2 Test certificates (Clause 4.1.2)

Record keeping of test certificates shall be included in the Contractor's quality documentation

24.4.1.3 Painting and Corrosion Protection

All steelwork surfaces that are to be painted or otherwise treated shall be prepared and treated in accordance with Section 37 – Painting and Corrosion Protection. Where friction bolts (HSFG) are specified, surface preparation shall be indicated on the drawings such as to ensure full friction grip of the connection.

24.4.1.4 Structural Fasteners (Clause 4.1.5)

The classes and grades of the fasteners to be used shall be as shown in the drawings.

Generally the fastener grade to match bolt grade.

(a) Bolt grades

Grade 10.9 to be used for high strength friction grip bolts (HSFG) only. Where possible, the use of friction grip bolts should be avoided.

24.4.1.5 Substitution of Steel Quality and Shape (Clause 4.1.6)

The steel quality of components of the original design shall not be substituted.

24.4.2 Drawings

24.4.2.1 General (Clause 4.2.1)

(a) Fabrication Standards (Sub-clause 4.2.1.1)

The Contractor shall be responsible for the preparation of fabrication drawings (shop drawings). Drawing numbering and drawing standards shall comply with project drawing standards.

(b) Revisions (Sub-clause 4.2.1.2)

Drawing revisions format shall be in accordance with project drawing standards.

(c) Format of drawings (Sub-clause 4.2.1.3)

The electronic format of the drawings shall be AutoCAD and Adobe PDF.

24.4.2.2 Fabrication drawings (Clause 4.2.4)

(a) General (Clause 4.2.1.4)

The Contractor shall be responsible for the preparation of fabrication drawings (shop drawings).

The fabrication drawings and supporting calculations, if relevant, shall be submitted to the designer for approval and Engineer for review.

The fabrication drawings shall be numbered according to and comply with drawing standards per clause 24.4.2.

(b) Attachments to Facilitate Erection (Sub-clause 4.2.4.2 and 4.4.4.5)

Attachments to facilitate erections may not remain part of the permanent structure.

(c) Hole Sizes (Sub-clause 4.2.4.4)

Hole sizes for holding-down bolts in excess of 36 mm diameter shall be indicated on the construction and fabrication drawings.

(d) Connections to allow Movement (Sub-clause 4.2.4.7)

Connections that are designed to allow movement shall be fabricated as detailed on the construction drawings.

(e) Machining (Sub-clause 4.2.4.8)

Requirements for machining shall be indicated on the construction and fabrication drawings.

24.4.3 Workmanship – General

24.4.3.1 Identification (Clause 4.3.1)

(a) Material Grade Identification (Sub-clause 4.3.1.1)

All steel elements shall be marked in such a way as to be traceable to a specific cast or heat of steel.

24.4.3.2 Cutting and Shaping (Clause 4.3.3)

(a) Cutting Operations (Sub-clause 4.3.3.1)

Cut edges that will remain exposed shall be ground to achieve a smooth and straight surface.

24.4.4 Workmanship – Welding

24.4.4.1 Site Welding (Additional Clause)

Site welding will not be permitted unless it is dictated by the design and indicated on the drawings or approved by designer.

24.4.5 Workmanship – Bolting

24.4.5.1 Ordinary Bolted Assemblies (Cause 4.5.1)

(a) Washers (Sub-clause 4.5.1.4)

Washers under nuts and bolt heads on flat surfaces are required.

24.4.6 Workmanship – Erection

24.4.6.1 Alignment and levelling (clause 4.6.3)

(a) Temperature effects (sub-clause 4.6.3.2)

The reference temperature shall be 27^{o}C.

24.5 COMPLIANCE WITH THE REQUIREMENTS

24.5.1 Non-destructive Testing of Welds

24.5.1.1 Ultrasonic and Radiographic Examination (Clause 5.3.4)

Should ultrasonic or radiographic examination be required it shall be specified / indicated on the drawings.

24.5.1.2 Scope of Inspection (Clause 5.3.5)

Where non-destructive testing, other than visual inspection in accordance with the criteria of ANSI/AWS D1.1/D1.1m is required, it shall be indicated on the construction drawings.

24.6 SUNDRY STEELWORK ITEMS

24.6.1 Access Ladders, Handrails, Open Grid Covers and Cover Plates

Details of access ladders, crane maintenance access platforms, handrails, open grid covers and cover plates shall be shown on the drawings. The type of steel and corrosion protection shall be indicated on the drawings and comply with Section 37 – Painting and Corrosion Protection.

The Contractor shall confirm all dimensions on site before the commencement of fabrication of these items. The items shall be supplied to site complete with all necessary fixing bolts, nuts, etc.

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SECTION 25

ROADWORKS AND PAVING

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ROADWORKS AND PAVING

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SECTION 25
ROADWORKS AND PAVING

25.1 SCOPE

This Section deals with the work required for the construction of pavement layers, and finishing work for roads, pavements and parking areas. This Section also covers the construction of concrete block paving for roads, erection of guardrails and painting of road markings.

The Standard Specifications for Roads and Bridge Works for South African Road Authorities, prepared by the Committee of Transport Officials (COTO), as amended, shall apply.

The scope of works generally includes:

a) Permanent access roads;
b) Pumping station yards;
c) Temporary access roads;
d) Pipeline access and maintenance roads; and

25.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

25.2.1 Definitions

a) **"Pavement layer"** or "**Layer work"** means the upper layers of the road comprising the selected layers, subbase, base, wearing course and shoulders.
b) **"Shoulder"** means:
   i) When shoulder is referred to as a surface: The area between the outside edge of the travelled way and the shoulder breakpoint.
   ii) When shoulder is referred to as a pavement: The layer on top of the subbase and lying between the outside edge of the base or, as applicable, wearing course and the shoulder breakpoint.
c) **"Shoulder breakpoint"** means the line along which the extended flat planes of the surface of the shoulder and the outside slope of the fill and pavement intersect. This edge is normally rounded to a predetermined radius.
d) **"Subbase"** means the layer of material of specified dimensions on top of the selected fill and below the base and shoulders.
e) **"Wearing course"** means a layer of material of defined thickness and width constructed on top of the selected layer in the case of an unsurfaced road.
f) **"Base"** means a layer of material of defined thickness and width constructed on top of the subbase, or in the absence thereof, the selected layer. A base may extend to outside the travelled way.
g) **"Grading Coefficient (Gc)"** means the product of the percentage by mass, of the total sample, retained between the 26.5 mm and 2 mm sieves multiplied with the percentage by mass, of the total sample, passing the 4.75 mm sieve, divided by 100.

h) **"Oversize Index (Io)"** means the mass of material retained on the 37.5 mm sieve, as a percentage of the total mass of the material.

i) **"Shrinkage Product (Sp)"** means the product of the linear shrinkage and the percentage by mass of the total sample passing the 0.425 mm sieve.

j) **"Bedding"** shall mean the layer of sand placed between the top of the subbase and the bottom of the paving block.

k) **"Paving block"** shall mean a precast concrete paving block of such size that it can be lifted and laid with one hand, with approximate dimensions as follows: length = 200 mm; width = 100 mm; thickness = 50 – 120 mm; and there are normally 40 – 50 blocks per square metre of paved area.

l) **"TRH 20"** shall mean a manual published by the CSIR: The Structural Design, Construction and maintenance of unpaved roads.

25.2.2 Abbreviations

AASHTO: American Association of State Highway and Transportation Officials
BS: British Standard
CBR: Californian Bearing Ratio
CEM: Calcium Enriched Mixture (Cement)
COLTO: Committee of Land Transport Officials
CSIR: Council for Scientific and Industrial Research
EC: Electrical conductivity
GM: Grading Modulus
LL: Liquid Limit
LS: Linear Shrinkage
MDD: Maximum Dry Density
NITRR: National Institute of Technology Raipur
OMC: Optimum Moisture Content
PD: Permissible Deviation
PI: Plasticity Index
SANS: South African National Standard
TMH: Technical Methods for Highways

25.2.3 References

Where reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

25.3 LAYER WORK AND SURFACING

25.3.1 Materials

25.3.1.1 Selected layer

Selected layer material shall, unless otherwise specified by the designer, conform to the requirements given in Table 25/1 when finally placed.

TABLE 25/1
REQUIREMENTS FOR SELECTED LAYER

TYPE OF MATERIAL	G7
DESCRIPTION OF MATERIAL	Natural material (soil, sand or gravel)
ADDITIONAL FINES	Not applicable
NOMINAL MAXIMUM SIZE	i) Uncrushed material: Two thirds of the compacted layer thickness. ii) Crushed material: 75 mm
GRADING MODULUS (GM)	2.7 ≥ GM ≥ 0.75
ATTERBERG LIMITS FOR NATURAL MATERIAL (-0,425 MM FRACTION)	The PI shall not exceed 12 or a value equal to 3 times the GM plus 10, whichever is the higher value. In the case of calcrete the PI shall not exceed 17 provided that the LS does not exceed 7% and (% passing 0.425 mm sieve) LS ≤ 320.
SWELL (MAX)	Swell at 100% of modified AASHTO density shall not exceed 1,5%.
STRENGTH (CBR)	CBR at 93% of modified AASHTO density shall be at least 15%.
COMPACTION REQUIREMENTS	95% of modified AASHTO density.

25.3.1.2 Subbase Layer

Subbase layer material shall, unless otherwise specified by the designer, conform to the requirements given in Table 25/2 when finally placed.

TABLE 25/2
REQUIREMENTS FOR SUBBASE

CRITERIA	SUBBASE - G5
Parent Material	Natural gravel or natural gravel and boulders which may require crushing, or crushed rock.
Additional Fines	May contain suitable natural fines not obtained from parent rock.
Strength	CBR at 95% of Mod. AASHTO max. density shall be at least 45%. Swell at 100% of Mod. AASHTO max. density shall not exceed 0.5%.
Durability	Mudrock only to be used if directed by the Engineer.

CRITERIA	SUBBASE - G5
Shapes	All alluvial or colluvial material shall be crushed that at least 50% (by mass) of the fraction retained on the 4.75 mm sieve has at least one fractured face.
Atterberg Limits	LL shall not exceed 30. PI shall not exceed 10, except that if less than 30% of the sample passes the 2.00 mm sieve, the PI shall not exceed 12. LS shall not exceed 5%.
Grading	The maximum size of crushed material shall be 53 mm before compaction. The maximum size of uncrushed material shall be 63 mm. The percentage (by mass) passing the 2.00 mm sieve shall be not less than 20% and not more than 70%. Grading modulus shall be not less than 1.5 and not more than 2.5.
Compaction	The minimum dry density of the compacted layer shall be 95% of modified AASHTO density.

25.3.1.3 Gravel Wearing Course

The gravel wearing course material shall, unless otherwise specified by the designer, conform to the requirements given in Table 25/3 when finally placed.

TABLE 25/3
REQUIREMENTS FOR GRAVEL WEARING COURSE

PARAMETER	LIMIT	
	TYPE 1 (Urban)	**TYPE 2 (Rural)**
Maximum size, mm	37.5	37.5
Oversize Index (I_o) (maximum), %	0	< 5
Shrinkage product (Sp)	100-240	100 – 365 (maximum of 240 preferable)
Grading coefficient (Gc)	16 – 34	16 – 34
CBR at ≥ 95% modified AASHTO Compaction (soaked value) (minimum), %	≥ 15	≥ 15
I_o = Oversize index (per cent retained on 37.5 mm sieve) Sp = Linear shrinkage x per cent passing 4.25 mm Gc = (Per cent passing 26.5 mm – per cent passing 2.0 mm) x per cent passing 4.75 mm/100		

Note: All parameters in Table 25/3 are defined in TRH 20.

25.3.1.4 Chemically Stabilized Pavements Layers

The chemically stabilised pavement layers shall, unless otherwise specified by the designer, conform to the requirements of Table 25/4 when finally placed.

TABLE 25/4
REQUIREMENTS FOR CHEMICALLY STABILIZED PAVEMENT LAYERS

Criteria	C3	C4
Material before treatment	G5 quality	G6 quality
Atterberg limits after treatment	PI shall not exceed 6	
Design strength (MPa)		
(a) At 100% of modified AASHTO density	Minimum: 1.5 Maximum: 3	Minimum: 0.75 Maximum: 1.5
(b) At 97% of modified AASHTO density	Minimum: 1 Maximum: 2	Minimum: 0.5 Maximum: 1
Indirect tensile strength at 100% of modified AASHTO density (kPa)	Minimum: 250	Minimum: 200
Durability: Fines lost Wet-dry Freeze-thaw	Durability: The wet dry durability test shall be carried out to determine the durability of cement stabilized materials. Test method A19 (THM 1: Standard Test Methods for Road Building Materials) shall apply. The percentage material loss after 12 cycles shall not exceed 14%.	

25.3.1.5 Compaction Requirements

The minimum in-situ dry density of gravel material shall be as specified hereinafter for the respective layers in terms of a percentage of modified AASHTO density.

Subbase: 97% for material not chemically stabilized.
96% for chemically stabilized material.
Shoulder and wearing course: 95%.

25.3.1.6 Soluble Salinity

The soluble salinity of base material shall be subject to the following:

(a) Soluble Salts

The percentage of soluble salts in the materials shall be subject to the following provisions:

- Untreated material (< 6.7 mm fraction);
- Witwatersrand quartzite: Crushed stone and mine stone;
- Where the pH < 6.0, the material shall be treated with lime until pH $\geq$ 10, and then used. (The aggregate is normally treated at the crusher, and if the pH exceeds 10 at that stage, the decrease which will occur later on, shall be ignored should it remain $\geq$ 8.0); and
- Where the pH $\geq$ 6.0, the material is used as it is.

(b) Other Materials such as Natural Gravel and other Crushed Stone

- Where the electrical conductivity (EC) $\leq$ 0.15 Sm $\cdot^{1}$, material may be used;
- Where the EC $\geq$ 0.15 Sm $\cdot^{1}$, the pH shall be determined;
- Where the pH $\leq$ 6.0, the material shall be treated with lime until the pH $\geq$ 10. The material may then be used. (Any later decrease of the pH shall be ignored should it remain $\geq$ 8.0); and
- Where the pH $\geq$ 6.0, it may be used, but special attention should be given to design and construction measures.

(c) Material being stabilized (for example with lime or cement)

- Where the pH $\geq$ 6.0 and the EC $\leq$ 0.02 Sm$\cdot^{1}$ and the qualitative test shows that sulphates do not pose a problem, the material may be used. If not, the material shall not be used; and
- The tests conducted for determining the above judgement parameters shall include the following:

–	Electrical conductivity (EC)	-	Method A21T of TMH1 (< 6.7 mm fraction)
–	Qualitative sulphate test	-	NITRR method CA21 (< 6.7 mm fraction)
–	ph	-	NITRR method CA 21 (< 6.7 mm fraction)

Where the salinity of the water used for compaction purposes is so high as to cause an increase in the salinity of the material, the Engineer shall be entitled to determine the soluble salinity from samples taken from any section of the compacted layer within 24 hours, and also before the surfacing is applied.

25.3.1.7 Chemical Stabilizing Agents

The stabilizing agent shall be either one or more of the following agents as specified.

(a) Road Lime

Road lime shall comply with the requirements of SANS 824 and shall bear the SABS mark.

(b) Stabilizing Cement

Cement shall comply with the requirements of SANS 50197-1. Cement used in stabilization shall be CEMII/B-V 32.5 or equivalent.

25.3.2 Construction

25.3.2.1 Selection, Placing and Compaction

(a) Selection

The maximum sizes shall be:

- Rock fills 750 mm maximum dimension
- Normal fills 500 mm maximum dimension
- Pavement layers 300 mm maximum dimension

Pavement materials shall be further broken down to the sizes as specified for each layer.

(b) Placing

When the layer thickness after compaction is 200 mm or less, any oversized material which cannot be broken down to the required size shall first be removed from the road.

The layer thickness shall comply with the requirements as indicated on the drawings.

(c) Spraying and Mixing

Before the material is compacted, it shall first be thoroughly mixed to obtain an even mix of various types of material and to spread the fine and course material evenly throughout the mixture. If necessary, during the mixing process, water shall also be sprayed evenly over and mixed into the material to obtain the correct uniform moisture content.

(d) Compaction

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned, and the length of any section of the layer being compacted shall be not less than 150 mm nor more than can be properly compacted with the available equipment.

The compaction shall comply with the requirements as indicated on the drawings. The Contractor shall comply with Noise-induced hearing loss Regulation, obtain a noise permit from local authorities and comply with Construction Regulation 23, use of construction vehicles and mobile plant.

25.3.2.2 Foundation Preparation

Any roadbed material which is considered by the designer to be detrimental to the performance of the completed road shall be removed to such widths and depths as directed by the designer.

25.3.2.3 Layer works

(a) General

Each layer shall only be constructed if the underlying layer or fill conforms to the relevant requirements specified for that layer. Dumping of the material for the succeeding layer may not commence on a particular section of road unless the Engineer has inspected the current layer. Immediately before placing the material, the underlying layer or fill shall be checked by the Contractor for damage or deficiencies, which shall be made good.

The finally compacted layer shall be free from surface laminations, portions exhibiting segregation of the fine and coarse aggregates, corrugations, or other defects that may adversely affect the performance of the layer.

Where specified or required by the Engineer the prepared surface shall be treated with a herbicide and ant poison before the layer of sand for bedding is placed.

The Contractor shall protect and maintain the completed selected fill until the wearing course or block paving is constructed. Maintenance shall include the immediate repair of any damage or defects which may occur and shall be repeated as often as is necessary to keep the selected fill or subbase continuously intact. Repairs shall be done in a manner that will ensure restoration to an even and uniform surface.

(b) Shoulders

Adequate drainage shall be ensured during construction by means of temporary drainage pipes passing through the shoulders. The Contractor shall not start constructing the final surfacing of any part of the road before the completion of the shoulders of such section and inspection by the Engineer.

25.3.2.4 Chemical Stabilization

(a) Preparing the Layer

The material to be stabilized shall be prepared and placed as specified elsewhere in this Section, and given at least one pass with a flat wheel roller. The material shall be moist.

(b) Applying the Stabilizing Agent

After the layer of soil or gravel has been prepared, the stabilizing agent shall be spread uniformly over the full area of the layer. Pockets or bags of stabilizing agent shall be accurately spaced at equal intervals along the section to be stabilized so that the specified rate of application can be

achieved. The stabilizing agent shall be spread as evenly as possible, and shall then be uniformly distributed over the entire surface to be treated.

(c) Mixing in the Stabilizing Agent

Immediately after the stabilizing agent has been spread, it shall be mixed with the material for the full depth of treatment. Care shall be taken not to disturb the compacted layer underneath, nor to mix the stabilizing agent in below the desired depth. Mixing shall be continued for as long as necessary and repeated as often as required to ensure a thorough, uniform and intimate mix of the soil or gravel and the stabilizing agent over the full area and depth of the material to be treated. Mixing shall be done over the full area and depth of the layer to be stabilized by means of successive passes of the equipment.

(d) Watering

Immediately after the stabilizing agent has been properly mixed with the soil or gravel, the moisture content of the mixture shall be determined, and the required amount of water shall be added. Each application or increment of water shall be well mixed with the material to avoid the concentration of water near the surface or the flow of water over the surface of the layer. Particular care shall be taken to ensure satisfactory moisture distribution over the full depth, width and length of the section being stabilized and to prevent any portion of the work from getting excessively wet after the stabilizing agent has been added. The moisture content of the material during compaction shall never exceed 80% of the saturation moisture content of the natural material without stabilizing agent, calculated at maximum dry density. Any portion of the work that becomes too wet after the stabilizing agent has been added and before the mixture has been compacted shall be allowed to dry out to the required moisture content and shall then be scarified, re-stabilized, re-compacted and again finished off in accordance with the requirements specified herein.

(e) Compaction

During compaction, loss of moisture by evaporation shall be corrected by further light applications of water. During compaction of the stabilized layers, the Contractor shall lightly harrow or scarify the crust before final rolling, in order to prevent the formation of laminations near the surface of the layer. Final rolling shall be done with equipment that will give a smooth surface finish which conforms to the surface tolerances specified. Low patches on the surface may not be filled after compaction. The minimum compaction requirements shall be as specified for the particular layer in the various parts of this Section.

(f) Finishing at Junctions

Any finished portion of the stabilized layer adjacent to new work, which is used as a turn-round area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil

or gravel of at least 100 mm thick over a sufficient length to prevent damage to work already completed. When the adjoining section is being finally finished, such cover shall be removed to permit the making of a smooth vertical joint at the junction of the different sections.

(g) Curing the Stabilized Work

The stabilized layer shall be protected against rapid drying out for at least seven days following completion of the layer. The stabilized layer shall be kept continuously wet or damp by watering at frequent intervals. This method will be permitted for up to a maximum period of 24 hours, thereafter the layer shall be covered with the material of the next layer as soon as the moisture content of the stabilized layer permits. Work which is not kept continuously wet or damp to the satisfaction of the Engineer, but is subjected to consecutive wet-dry cycles, may be rejected by the Engineer should he consider the layer to have been adversely affected. The stabilized layer shall be covered with the material required for the next layer while the stabilized layer is still wet or in a damp condition. The material forming the protective layer shall be watered at such intervals as may be required to keep the stabilized layer continuously wet or damp, and in dry weather this shall be done at least once in every 24 hours.

(h) Construction Limitations

For cemented layers, the stabilizing agent shall be applied only to a surface the size of which will permit all processing, watering, compacting and finishing to be completed within the period given in Table 25/5. For modification only, the maximum period allowed from the time the stabilizing agent comes into contact with the layer being modified until the completion of compaction shall be 48 hours in the case of slaked or unslaked lime. The starting time shall be the median time taken to complete the spreading of all the lime. No stabilization shall be done during wet weather or when windy or freezing conditions may adversely affect the stabilizing operations.

TABLE 25/5
CONSTRUCTION LIMITATIONS FOR STABILISED LAYERS

STABILIZING AGENT	**Maximum continuous period allowed from the time the stabilizing agent comes into contact with the layer being stabilized until the completion of compaction (see note)**
CEM II	6 hours
Slaked lime	10 hours
Unslaked lime	10 hours

Note: Starting time shall be the median time taken to complete the spreading of the stabilizing agent.

No traffic or any equipment not actually used for processing the layer may be allowed to pass over the freshly spread stabilizing agent. Only equipment required for curing may be allowed over the treated layers during the specified curing period.

25.3.2.5 Construction Tolerances

(a) Level for Subbase, Shoulders and Wearing Course

At least 50 level measurements shall be taken according to a stratified random pattern of each section of the completed layer, and the specified levels shall then be determined.

The lot will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90% of the level measurements show a deviation of less than 20 mm from the specified levels. Isolated spots, where the surface levels deviate by more than 25 mm of the specified levels shall be repaired to bring the deviation to within 20 mm.

(b) Layer Thickness for Subbase, Shoulders and Wearing Course

At least 30 mm layer thicknesses shall be determined in accordance with a stratified random pattern for each lot of completed layer work. Layer thickness may be determined by means of level measurements taken before and after construction of the layer in exactly the same position, but may be augmented by thickness measurements taken by means of holes made in the layer.

The lot will be considered to comply with the requirements for layer thickness if:

- At least 90% of all the thickness measurements taken before any thickness repairs are made is equal to or greater than the specified thickness, minus 21 mm; and
- The mean layer thickness of the lot is not less than the specified thickness minus 5 mm. Isolated spots where the actual thickness is less than the specified thickness less 27 mm shall be repaired so as to fall within the 21 mm tolerance.

(c) Compaction of Subbase, Shoulders and Wearing Course

At least 4 relative density determinations shall be taken in the case of fill and selected fill in accordance with a random pattern. After outliers have been examined and replaced, compliance with the specified density requirements shall be determined in accordance with Table 25/6.

TABLE 25/6
SPECIFIED DENSITY REQUIREMENTS

Prescribed compaction	Unit of measurement	Minimum average relative compaction for the following sample sizes						Minimum value for any single test for the following sample sizes					
		4	5	6	7	8	9	4	5	6	7	8	9
93%	Mod. AASHTO density	93.1	93.4	93.6	93.7	93.9	94.0	89.4	89.2	89.0	88.9	88.8	88.7

95%	Mod. AASHTO density	95.1	95.4	95.6	95.7	95.9	96.0	91.4	91.2	91.0	90.9	90.8	90.7
96%	Mod. AASHTO density	96.1	96.4	96.6	96.7	96.9	97.0	92.4	92.2	92.0	91.9	91.8	91.7
97%	Mod. AASHTO density	97.1	97.4	97.6	97.7	97.9	98.0	93.4	93.2	93.0	92.9	92.8	92.7

(d) Rate of Application of Chemical Stabilizing Agents

The rate of application of a chemical stabilizing agent, when applied by mechanical bulk spreading equipment and measured by the canvas-patch method, shall be equal to the specified rate of application, ±5% measured over any section not exceeding 1.0 km in length, and no single measurement shall show a value deviating by more than 20% from the specified rate.

25.3.3 Testing

25.3.3.1 Acceptance Testing

The total number of tests required to determine compliance of the aggregate for the subbase is given in Table 25/7.

TABLE 25/7
TESTS FOR ACCEPTANCE OF SUBBASE MATERIAL

CBR	2
Atterberg Limits	3
Grading	3

25.3.3.2 Routine Testing

The testing frequencies and sample and lot sizes shall be as specified in Table 25/8.

TABLE 25/8
MINIMUM SAMPLING AND TESTING FREQUENCIES

PAVEMENT LAYER	PROPERTY	SAMPLING FREQUENCY
Subbase	Grading, Grading Modulus and Atterberg Limits	1 Sample/200 m³ with min 6 samples/lot*
	CBR + CBR Swell	1 Sample per 900 m³
	Compaction : MDD : Density	2 Samples/lot* 6 Samples/lot*
Wearing Course	Grading	1 Sample/600 m³
	Atterberg Limits	1 Sample/300 m³ with min 2 samples/lot*
	CBR + CBR Swell	1 Sample/material type with

PAVEMENT LAYER	PROPERTY	SAMPLING FREQUENCY
		min 1 sample/1 800 m³
	Compaction : MDD : Density	1 Sample/material type with min 1 Sample/1 800 m³ 1 Sample/500 m³ with min of 3 samples/lot*
Surfacing stone - Use acceptance testing results		

Note:

* A "lot" is a day's work, except where the material or manner of processing changes, such change signifying the end of the lot.
MDD means Maximum Dry Density.

25.4 CONCRETE BLOCK PAVING

25.4.1 Materials

25.4.1.1 Bedding Sand

A layer of bedding sand shall be placed on top of the prepared surface of the underlying pavement layer. Bedding sand for concrete block paving shall not contain any deleterious impurities, clay or silt material.

The bedding sand shall comply with the grading requirements shown in Table 25/9 below:

TABLE 25/9
BEDDING SAND GRADING REQUIREMENTS

SIEVE SIZE (MM)	% PASSING THROUGH
9.52	100
4.75	95 - 100
2.36	80 - 100
1.18	50 - 85
0.600	25 - 60
0.300	10 - 30
0.150	5 - 15
0.075	0 - 10

25.4.1.2 Jointing Sand

Jointing Sand shall be worked in between the individual blocks in order to lock the blocks in position. The jointing sand shall comply with the grading requirements in Table 25/10 below:

TABLE 25/10
JOINTING SAND GRADING REQUIREMENTS

SIEVE SIZE (MM)	% PASSING THROUGH
2.36	100
1.18	90 - 100
0.600	60 - 90
0.300	25 - 60
0.150	10 - 25
0.075	10 - 15

25.4.1.3 Concrete Paving Blocks

Concrete paving blocks shall comply with the requirements of SANS 1058. The block shall be of the class, type and thickness specified on the drawings. The surface texture and colour of all blocks shall be uniform.

The concrete paving bricks shall be Type S-A, Class 25 and 80 mm thick, unless otherwise specified by the designer.

Cast in-situ concrete edge beams or intermediate beams shall be constructed in accordance with the provisions of Section 20 – Concrete Works (Structural). Prefabricated kerbing and channelling shall comply with the requirements of Section 20 – Concrete Works (Structural) and Section 27 – Drainage and Erosion Protection.

25.4.1.4 Herbicide and Ant Poison

The herbicide and ant poison shall be environmentally friendly and shall be subject to the Engineer's approval. When handling hazardous chemicals, the Contractor shall comply with Hazardous chemicals substances Regulation 5: Potential exposure of employees, 7 Medical surveillance, 8 Respirator zone, 9A Handling of Hazardous chemicals, 10 Control of exposure to HCS and 11 Personal Protective Equipment.

25.4.1.5 Invert Emulsion Primer

The priming material shall be an invert bitumen emulsion complying with SANS 1260.

25.4.2 Construction

25.4.2.1 Placing of Concrete Block Paving

All the blocks shall be laid in a herringbone pattern unless otherwise specified by the Engineer.

25.4.2.2 Priming of Subbase Layers

The subbase layer shall be primed prior to the placing of bedding sand for the concrete block paving with an emulsion primer at a nominal rate of 0.7 litres/m².

No prime shall be applied under adverse weather conditions as described below:

a) During foggy or wet conditions;
b) When rain is imminent;
c) When wind is blowing hard enough to cause uneven spray;
d) When the surface of the layer is visibly wet;
e) After sundown; and
f) When the temperature of the surface is below 10˚ C.

The prime shall be sprayed at a spraying temperature of between 20 – 60˚ C.

The Contractor shall take adequate measures to protect any kerbing or paving from overspray caused during the priming operation.

25.4.2.3 Laying of Units

Paving blocks shall be laid such that a joint width of 2 mm to 5 mm forms between each paving block with a target joint width of 3 mm. Mechanical force shall not be used to bring the paving blocks into contact.

Heavy equipment shall not be permitted to run over the un-compacted, unlocked area of the wearing surface.

Full depth closure units, saw cut from whole units, shall be fitted into gaps around the perimeter and around service installations such as manholes. Any space, of which the size is less than 25% of the size of an unbroken block, shall be filled with 35/12 G50 concrete. The area shall be laid as far as possible using whole paving blocks. Infilling shall be completed before compaction commences.

After the paving blocks have been laid, the pavement shall be compacted by two passes of a suitable vibrating-plate compactor operating at a frequency of 65 Hz to 100 Hz and low amplitude. The compactor's plate surface shall be 0.2 m² to 0.4 m² and it shall develop a centrifugal force of 7 kN to 16 kN.

After compaction of the pavement as described above, dry jointing sand shall be spread and brushed into the joints until the joints have been properly filled. Any surplus sand shall then be broomed off and the pavement shall then be subjected to two further passes by the compactor.

25.4.2.4 Edge Beams and Intermediate Beams

Cast in-situ or prefabricated concrete edge beams and intermediate beams shall be constructed on the underlying pavement layer in accordance with the details shown on the drawings. No paving blocks shall be laid before the edge and intermediate beams have developed sufficient strength to withstand the construction forces.

Expansion joints shall be placed every 6 m. The expansion joint shall be 10 mm wide and shall be filled with a dark grey coloured polysulphide sealant.

25.4.2.5 Tolerances

The completed concrete block paving shall comply with the following construction tolerances:

TABLE 25/11
CONCRETE BLOCK PAVING CONSTRUCTION TOLERANCES

LINE OF PATTERN	TOLERANCES
Maximum deviation from any 3 m straight line	10 mm
Maximum deviation from any 20 m straight line	20 mm
Vertical:	
Vertical deviation from a 3 m straight-edge	±3 mm
At the edge beams	0 mm
Elsewhere	± 10 mm
Maximum difference in the surface levels of adjacent units	5 mm

25.5 ROAD MARKINGS

25.5.1 Materials

Retro-reflective road-marking paint shall comply with the requirements of SANS 731-1 and CKS 192. The no-pick-up time of road marking paint shall comply with the Class 1 requirement in SANS 731-1.

The paint shall be delivered to the Site in sealed containers marked in accordance with SANS 731-1. The viscosity of the paint shall be such that it can be applied without being thinned down.

The colours to be used shall be bright white, yellow or red, as specified in SANS 731 – 1.

25.5.2 Weather Limitations

Road-marking paint shall not be applied to a damp surface or at temperatures lower than 10° C, or when the wind strength is such that it may adversely affect the painting operations.

25.5.3 Surface Preparation

Before the paint is applied, the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material which would be detrimental to the bond between the paint and the surface. The surface where the paint is to be applied shall be properly cleaned by means of watering, brooming or compressed air if required. Where road markings are to be applied to a concrete pavement, all laitance and loose curing compound shall first be removed.

25.5.4 Setting Out the Road Markings

The dimensions and positions of road markings shall be as shown on the drawings or as specified in the appropriate statutory provisions and the South African Road Traffic Signs Manual. The lines, symbols, figures or marks shall be pre-marked by means of paint spots of the same colour as that of the final lines and marks. These paint spots shall be at intervals to ensure that the traffic markings can be accurately applied, and in no case shall they be more than 1.5 m apart. Normally spots of approximately 10 mm in diameter should be sufficient. After spotting, the positions of the proposed road markings such as broken lines and the starting and finishing points of barrier lines shall be indicated on the road. These pre-markings shall be agreed by the Engineer prior to any painting operations being commenced. The positions and outlines of special markings shall be produced on the finished road in chalk and shall be subject to the Engineer's inspection before they are painted. Templates may be used on condition that the positioning of the marking is agreed by the Engineer before painting is commenced.

25.5.5 Applying the Paint

The figures, letters, signs, symbols, broken or unbroken lines or other marks shall be painted as shown on the drawings. Where the paint is applied by machine, it shall be applied in one layer. Before the road-marking machine is used, the satisfactory operation of the machine shall be demonstrated on a suitable site which is not part of the Permanent Works. Adjustments to the machine shall be followed by further testing. Only when the machine has been correctly adjusted after testing, may the machine be used on permanent work.

Where two or three lines are required next to each other, the lines shall be applied simultaneously by the same machine. The paint shall be stirred before application in accordance with the manufacturer's instructions. Paint shall be applied without the addition of thinners. Where, under special circumstances, painting is done by hand, it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried out sufficiently. As most road-marking paint reacts with the bitumen surface of the road, the paint shall be applied with one stroke only of the brush or roller. Ordinary road-marking paint shall be applied at a nominal rate of 0.42 ℓ/m^2. The road marking shall be completed before a particular section of the road is opened to traffic. Each layer of paint shall be continuous over the entire area being painted. The Contractor shall comply with Construction Regulation 25 - Use and storage of flammable liquids when doing road markings.

25.5.6 Tolerances

The width of lines and other markings shall not be less than the specified width, nor shall it exceed the specified width by more than 10 mm.

The position of lines, letters, figures, arrows, retro-reflective road studs and other markings shall not deviate from the true position by more than 100 mm in the longitudinal and 20 mm in the transverse direction.

The alignment of the edges of longitudinal lines shall not deviate from the true alignment by more than 10 mm in 15 m.

The length of segments of broken longitudinal lines shall not deviate by more than 150 mm from the specified length.

25.5.7 Applying the retro-reflective beads

The rate of application of the beads shall be 0.8 kg/ℓ of paint.

25.5.8 Roadstuds

The type and position of roadstuds shall be specified by the designer.

The roadstuds shall be fixed by means of a suitable epoxy resin, in accordance with the manufacturer's instructions. The studs shall be protected against impact until the adhesive has hardened. Before fixing the roadstuds, the surface shall be thoroughly cleaned.

Permanent roadstuds shall be fixed after the painting of the road lines. Painting over roadstuds is prohibited.

25.6 ACCOMMODATION OF TRAFFIC

25.6.1 General

The Contractor shall be responsible to ensure the safe and normal flow of traffic and access to properties at areas affected by the Works. The Contractor shall before any traffic accommodation is implemented, draft a Traffic Management Plan that will be submitted to the local traffic department for approval. The Contractor will only be allowed to implement traffic accommodation with a stamped and signed Traffic Management Plan from the local authorities. The Contractor shall comply with the National Road Traffic Act.

The Contractor shall not commence with any part of such works before adequate provision has been made for the accommodation of traffic and access to properties.

The safety of the public is of utmost importance and every effort must be made to ensure that all road signs, barricades, delineators, flagmen and speed controls are maintained and effective and that courtesy is extended to the public at all times.

The Contractor shall appoint a knowledgeable member of his staff on Site (Traffic Supervisor) and TSO (Traffic Safety Officer) who shall be the responsible person for the arrangements and maintenance of all accommodation of traffic and access measures required for the duration of the Contract. The Traffic Supervisor and TSO will need to be in possession of a valid training certificate. The responsible person shall liaise daily with the Engineer in order to maintain proper traffic management.

The Traffic Supervisor and TSO will be required to perform at least the following duties:

a) Be responsible for maintaining the temporary traffic accommodation requirements for 24 hours a day 7 days a week and implement stop/go if and when required;
b) Compile and maintain a daily record of traffic signs installed and the traffic signs sequence at each location during the Contract period;
c) Inspect and report to the Engineer on the state of all erected road signs at a frequency not less than once a day;
d) Exercise control in terms of traffic safety and the safe movement of personnel, visitors and Equipment on Site including the wearing of high visibility clothing, the operation of amber flicker lights, placement of delineators, installation of jersey barriers where required and the display and cleanliness of “construction vehicle” signs, all in accordance with the relevant Occupational Health and Safety Act and Construction Regulations 23;
e) Be responsible for keeping all road signs and traffic control devices clean and visible at all times;
f) Compile records and reports of traffic accident scenes which could be connected with the Works;
g) Attend to the training and performance of flagmen and all other personnel involved in the control of traffic conducted by a certified training provider; and
h) Attend to all complaints and claims from the public with regard to traffic safety and access and report on such matters to the Engineer.
i) All construction vehicles from the Contractor which includes trucks and machinery, shall travel between 15km/h to 30km/h.

25.6.2 Traffic Control Facilities

The Contractor shall provide, erect and maintain the necessary traffic control devices, road signs, channelization devices, barricades, warning devices and road markings (hereinafter referred to as traffic control facilities), as shown on the drawings and in accordance with the South African Road Traffic Signs Manual, and shall remove it when no longer required. The Contractor shall ensure that the traffic control facilities are present at all times and functioning properly. The Contractor shall

submit the design of the traffic-control facilities for the Engineer's review prior to establishing these facilities.

The Contractor shall immediately make good any shortcomings or defects to the temporary traffic control facilities.

The type of construction, spacing and placement of traffic-control facilities shall be in accordance with the prescriptions and recommendation of the latest edition of the South African Road Traffic Signs Manual, and in accordance with the drawings.

Traffic control facilities include the use of flagmen, portable "STOP" and "GO" signs, and traffic signals, whichever may be the most suitable method under prevailing circumstances. Traffic signals shall be erected in compliance with the design of the temporary works.

If the road is partially closed and one-way traffic only is allowed over a section of road, the traffic shall be regulated by flagmen and STOP and GO-RY signs at both ends of such section. Where necessary for effective communication between the flagmen, a two-way communication system shall be in operation at the control points. If the closure extends into the night, lighting and temporary traffic signals shall be provided or a deviation needs to be constructed.

25.6.3 Warning Devices

All construction vehicles and Contractor's Equipment used on the Works shall be equipped with rotating amber flashing lights. All lights shall be visible at all times and from all sides. The flashing lights shall be switched on at all times when the vehicles and Equipment are used on the Site.

25.6.4 Half Widths Roads

Where the construction of temporary road deviations is not feasible to facilitate the construction of the Works, the Contractor shall accommodate traffic by closing half the width of the road. Provision shall be made for traffic traveling in opposite directions to pass at frequent intervals.

The Contractor shall ensure that the entire road width shall be open at night, in a good and safe trafficable condition.

During the day the traffic shall be controlled by a STOP and RY / GO system.

Should the road not be in a safe trafficable condition for two-way traffic over the entire width at the end of each day's work, the Contractor shall provide adequate flagmen, signs, barricades, lights etc. to ensure the safe flow of traffic alternately in each direction.

25.6.5 Road Deviations

Road deviations shall be constructed 8 m wide with a pavement as follows:

- 150 mm gravel wearing course compacted to 93% of Modified AASHTO density;
- 150 mm selected layer compacted to 93% of Modified AASHTO density (G7 material);
- Fill layers if required compacted to 90% of Modified AASHTO density; and
- Roadbed preparation and compaction to 90% of Modified AASHTO density.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 26

ROAD MAINTENANCE

TCTA MODULAR STANDARDS
SECTION 26
ROAD MAINTENANCE

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SECTION 26
ROAD MAINTENANCE

26.1 SCOPE

This Section deals with the blading and re-gravelling of gravel roads and patching of bituminous surfaced roads used for the Works, as well as the reinstatement of existing roads where the pipelines crosses roads by means of trench excavation.

The Contractor shall be responsible for maintenance of existing and access roads that are being used for the Works, such as watering, blading and re-graveling.

26.2 DEFINITIONS AND REFERENCES

26.2.1 Definitions

a) **"Pavement layer"** or **"Layer work"** means the upper layers of the road comprising the selected layers, sub-base, base, gravel wearing course, asphalt surfacing and shoulders.

b) **"Shoulder"** means:
When shoulder is referred to as a surface - the area between the outside edge of the travelled way and the shoulder breakpoint.
When shoulder is referred to as a pavement - the layer on top of the sub base and lying between the outside edge of the base or, as applicable, wearing course and the shoulder breakpoint.

c) **"Shoulder breakpoint"** means the line along which the extended flat planes of the surface of the shoulder and the outside slope of the fill and pavement intersect. This edge is normally rounded to a predetermined radius.

d) **"Sub base"** means the layer of material of specified dimensions on top of the selected fill and below the base and shoulders.

e) **"Wearing course"** means a layer of material of defined thickness and width constructed on top of the selected layer in the case of an unsurfaced road.

f) **"Base"** means a layer of material of defined thickness and width constructed on top of the sub base, or in the absence thereof, the selected layer. A base may extend to outside the travelled way.

g) **"Grading Coefficient (Gc)"** means the product of the percentage by mass, of the total sample, retained between the 26.5 mm and 2 mm sieves plus the percentage by mass, of the total sample, passing the 4.75 mm sieve, divided by 100.

h) **"Oversize Index (Io)"** means the mass of material retained on a sieve of size equal to the nominal maximum specified size for the aggregate, as a percentage of the total mass of the material.

i) **"Shrinkage product (Sp)"** means the product of the linear shrinkage and the percentage by mass of the total sample passing the 0.425 mm sieve.

j) **"TRH 20"** shall mean a manual published by the SDIR: The Structural Design, Construction and maintenance of un-paved roads, 1990.

26.2.2 References

Where reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993 and Construction Regulation 2014.

26.3 MATERIALS

26.3.1 Fill

The material shall have a minimum CBR of 3% at 90% of Modified AASHTO density and a maximum PI of 15.

All new fills shall be compacted to a minimum of 93% Modified AASHTO density, however widening of existing fills shall be compacted to a minimum of 95% Modified AASHTO density.

26.3.2 Layer Works

Selected layer material shall, unless otherwise specified by the designer, conform to the requirements in Table 25/1 of Section 25 – Roadworks and Paving.

The gravel wearing course material shall, unless otherwise specified by the designer, conform to the requirements in Table 25/3 of Section 25 – Roadworks and Paving.

26.3.3 Patching

The bituminous binders shall comply with the following SABS specifications:

Road-grade bitumen	SANS 307
Bitumen emulsion	SANS 4001_BT3:2014 (anionic) SANS 548 (cationic)

26.4 CONSTRUCTION

26.4.1 Accommodation of Traffic

The following methods will be used to accommodate the traffic:

Blading/Reshaping	-	Restricted two-way traffic;
Re-gravelling	-	Half width – stop/go arrangement;
Culvert installation	-	Half width – stop/go arrangement;
Patching on major roads	-	Half width – stop/go arrangement; and
Excavations through roads	-	Gull width - deviation (gravel).

26.4.2 Earthworks and Layer Works

26.4.2.1 Scope

This section covers the blading of gravel roads by self-propelled motor grader to improve the rideability, correct drainage faults as well as to shape, trim and compact the formation to the required cross-sections and cambers.

It also covers the reconstruction of existing gravel roads and construction of new gravel wearing course on existing roads.

26.4.2.2 Clearing and Grubbing

Clearing shall consist of the removal of all trees, bush, other vegetation, rocks and boulders up to 0.15 m^3, rubbish, and all other undesirable material.

In the roadway, all stumps and roots exceeding 75 mm in diameter shall be removed to a minimum depth of 600 mm below the finished road level and a minimum of 75 mm below the original ground level. Where the roadbed is to be compacted, all stumps and roots, including matted roots, shall be removed to a depth of at least 200 mm below the cleared surface.

The cavities resulting from the grubbing shall be backfilled with suitable material and compacted to at least the density of the surrounding ground.

26.4.2.3 Treating the Roadbed

Treatment of the roadbed is required for the reconstruction of existing roads and construction of new roads.

Roadbed material that would be detrimental to the performance of the completed road shall be removed to such widths and depths as directed by the designer. The excavated spaces shall be backfilled with suitable material and compacted to the required density.

Material which is too wet to provide a stable platform for the construction of the fill or gravel layers shall also be removed and replaced with suitable dry material which may include a pioneer layer.

Any part of the roadbed which is classified as being suitable for use in situ, shall be scarified, watered and compacted to a minimum of 90% of Modified AASHTO density. The type and depth of compaction shall be as directed by the designer.

Where the thickness of the layer of imported material would be less than the specified layer thickness after compaction, then the roadbed material shall be scarified, the imported material placed, and this combined material mixed and compacted to the full specified depth of the layer.

All suitable materials excavated from the road prism shall be used for the construction of fills, pavement layers and mitre banks and for such other purposes as shown on the drawings.

26.4.2.4 Construction of Fills

The layer thickness used for the construction of the fills shall be maximum 200 mm.

The maximum size material for fill layers is 120 mm.

All new fills shall be compacted to a minimum of 93% of Modified AASHTO density. Widening of existing fills shall be compacted to a minimum of 95% Modified AASHTO density.

26.4.2.5 Reshaping and Compaction

Reshaping and compaction will be required where the existing gravel road has rutting, washboarding or corrugations, potholes, reduced water-runoff, etc. or where directed by the Engineer.

Reshaping and compaction will entail the cleaning of the formation of all vegetation by motor grader, followed by ripping, shaping, trimming, watering to optimum moisture content and compacting to the required cross-sections and cambers. This procedure shall also include cutting material from the sides to the crown and the shaping of the side drains.

Compaction shall be done to a minimum of 93% AASHTO density.

The Contractor shall perform acceptance control testing at a minimum of six densities and two CBR’s per kilometre of road.

26.4.2.6 Road Blading

Blading to improve the riding surface shall be done where potholes, corrugations and rutting caused by poor drainage, have developed.

Blading shall be carried out when gravel is at the optimum moisture content (normal blading). If the road surface is too dry for blading, it shall be watered ahead of the grader and during the blading operation (dry road blading). The Contractor shall determine the moisture content at which the material shall be bladed to facilitate the proper blading of the surface.

The first cut shall commence at the edge of the road and the material bladed towards the centre of the road. The first cut shall be at least as deep as the potholes and ruts. No undercutting or small windrows which will prevent water flowing freely off the road surface or into culvert inlets shall remain. During the blading operations all large stones and vegetation shall be removed from the windrowed material. Any drains blocked by under cutting shall be opened and gravel spillage into culvert inlets and outlets removed.

Prefabricated culverts shall be installed where required to allow sufficient drainage.

The road surface shall provide a smooth ride, free from corrugations and shall be properly drained.

The specified camber for straight sections of roads shall be maintained and super elevation on curves shall extend across the full width of the roadway.

26.4.2.7 Layer Works

Placing of the material for the next layer shall not commence on a particular section of road unless the current layer has been successfully tested. Immediately before placing the material, the underlying layer or fill shall be checked for defects and made good by the Contractor.

26.4.2.8 Construction Tolerances for Gravel Wearing Course

At least 10 layer thicknesses shall be determined in accordance with a stratified random pattern for each lot of completed layer work. Layer thickness may be determined by means of level measurements taken before and after construction of the layer in exactly the same position, but may be augmented by thickness measurements taken by means of holes made in the layer.

The lot will be considered to comply with the requirements for layer thickness if:

a) At least 90% of all the thickness measurements taken before any thickness repairs are made is equal to or greater than the specified thickness, minus 21 mm; and
b) The mean layer thickness of the lot is not less than the specified thickness minus 5 mm. Isolated spots where the actual thickness is less than the specified thickness less 27 mm shall be repaired so as to fall within the 21 mm tolerance.

26.4.2.9 Compaction of Gravel Wearing Course

The gravel wearing course shall be compacted to a minimum of 93% Modified AASHTO density. At least 4 relative density tests shall be done in the case of fill and selected fill in accordance with a random pattern. Densities shall comply with Table 25/6 of Section 25 – Roadworks and Paving.

26.4.2.10 Finishing of Slopes

The slopes of cuttings shall be trimmed to neat lines and to a standard which is generally attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed, especially in solid-rock cuts, which must be completely free from such material.

The final surface of side slopes shall have a slightly roughened surface which will be suitable for subsequent grassing or for establishing natural vegetation.

Fill slopes shall be finished to neat lines with all loose rocks and uncompacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slope but shall be as smooth as the material use allows.

No individual boulders occurring in otherwise smaller sized material shall be allowed to project beyond the surface.

All excess fill shall be removed.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break which can be discerned from the road. The degree of finish required for all fill and cut slopes flatter than 1 in 4 shall be such as normally obtainable by grader or hand-shovel operations.

26.4.2.11 Mechanical Modification

When the blending of materials from various sources is required, the material from the first source shall be dumped onto the road, prepared, broken down and spread in a layer of uniform thickness, after which it is lightly rolled with a steel-wheeled roller. The material from the second source shall then be dumped onto the road, prepared, broken down and evenly spread, after which the two materials shall be thoroughly mixed.

If necessary, water shall be added to the material to bring it to the correct moisture content not more than 2% above optimum moisture content.

26.4.3 Reinstatement of Existing Surfaced Roads

This section covers the excavation and patching of existing pavement layers, excluding resealing or resurfacing.

Patching shall be any work to existing pavement layers with the purpose of repairing local failures, and which is carried out in areas having a width of less than 1 m, or a length of less than 25 m, or an area of less than 100 m².

Patching involves excavating the existing failed sections and reinstating the excavated pavement layers with the specified pavement material.

Patching shall have a neat rectangular shape.

Excavation for patching shall be cut with side slopes of approximately 60º to the horizontal.

The excavations shall be backfilled with one or a combination of the following:

- Asphalt surfacing;
- Asphalt base;
- Cement stabilised crushed stone (G1);
- Cement stabilized gravel (5%); or
- Cement and Emulsion treated crushed stone (1.5% cement + 1.5% net bitumen).

Before production or delivery of the asphalt, the Contractor shall submit samples of the materials proposed to use in the mix, together with the proposed mix design as determined by a laboratory, to the designer.

The design of the asphalt mixes shall be in accordance with the design guidelines of TRH8 and appropriate research results, and the mix properties and requirements shall be as specified by the designer.

Compaction of asphalt surfacing and base will be executed in layers not exceeding 75 mm for the asphalt base and minimum layer thickness of 35 mm for asphalt surfacing

26.4.4 Finishing of Roads and Road Reserves

After completing the seal, surfacing or patching, or gravel surface on gravel roads, the road and road reserve shall be cleared of all excess earth, stones, boulders, debris, litter, garbage and other waste material resulting from the construction of the Works.

Culvert inlets and outlets, culvert barrels, and open drains shall be cleared of all debris, soil, silt and other material.

The road surface shall be cleared of all dirt, mud and foreign objects. Dragging, pushing or scraping material across the finished road surface shall not be permitted.

All junctions, intersections, islands, kerbing and other elements shall be neatly finished off.

All old roads, temporary deviations, haul roads and construction roads shall be levelled with the original ground. Surfaces shall be scarified and broken up to a depth of 150 mm.

Where required to prevent soil erosion, banks, dykes or ditches shall be constructed over the old road.

All temporary road signage shall be removed and existing road signage affected by the construction shall be re-instated.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 27

DRAINAGE AND EROSION PROTECTION

TCTA MODULAR STANDARDS
SECTION 27
DRAINAGE AND EROSION PROTECTION

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SECTION 27
DRAINAGE AND EROSION PROTECTION

27.1 SCOPE

This Section covers all work required for the construction of open drains, subsurface drains, prefabricated culverts, pipes, manholes, catch-pits and other permanent drainage structures, and stonework (pitching) and erosion protection.

Aspects of the Standard Specifications for Road and Bridge Works for State Road Authorities, Committee of Land Transport Officials (COLTO), South Africa, have been used as an industry standard guideline for the development of this Section.

27.2 ABBREVIATIONS, DEFINITIONS AND REFERENCES

27.2.1 Abbreviations

AASHTO: American Association of State Highway and Transportation Officials
ACB: Articulated Concrete Blocks
COLTO: Committee of Land Transport Officials
CSIR: Council for Scientific and Industrial Research
EN ISO: European Norm and International Standards Organisation
HDPE: High Density Poly Ethylene
OD: Outer diameter
PVC: Polyvinyl Chloride
SANS: South African National Standard
TMH: Technical Methods for Highways

27.2.2 Definitions

a) **"Articulated Concrete Block Systems"** means preformed concrete blocks that are interconnected through a combination of form and/or cables. The blocks are able to "articulate" along their adjoining faces, allowing the system to conform to changes in the subgrade while maintaining the protective cover. Open-cell forms allow vegetation to be established, improving stability and aesthetic appeal.

b) **"Catchwater drain or bank"** means a longitudinal drain or bank for diverting water.

c) **"Concrete pipe culverts"** mean prefabricated concrete pipes with circular sections.

d) **"Culvert"** means a structure other than a bridge, which provides an opening under a berm, carriageway or median for drainage or other purposes.

e) **"Geotextile"** means a synthetic-fibre filter fabric used for separation, filtration and drainage.

f) **"Inlet and Outlet drain"** means a channel along which water is to be led into or discharged from culverts, stormwater conduits and minor bridges.

g) **"Mitre drain and bank"** means a drain constructed at an angle to the centre line of a road to divert water away from side drains. Mitre drains include mitre banks placed across side drains.

h) **"Portal culverts"** or **"rectangular culverts"** means prefabricated concrete culverts other than pipe culverts.

i) **"Side drain"** means an open longitudinal drain situated adjacent to and at the bottom of cut or fill slopes.

j) **"Subsurface drain"** means a buried conduit constructed to intercept and remove subsurface water and includes any pipes and permeable material used in the construction of the drain.

k) **"Technical Methods for Highways (TMH)"** means a manual published by the CSIR. This Specification refers to TMH1 – Standard Methods of Testing Road Construction Materials, 1996.

27.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014, General Safety Regulation 5 - Work in confined spaces(manholes, pits etc.) and Construction Regulation 11 - Structures.

27.3 OPEN DRAINS AND BANKS

27.3.1 General

Open drains to channel surface water runoff and channels to direct the course of streams shall be constructed as shown on the drawings or as directed by the designer. In the construction of the drainage system, particular attention shall be paid to the prevention of soil loss and erosion.

Drains shall be provided where required at inlets and outlets to culverts as shown on the drawings or as directed by the designer. Where necessary earth banks, pitching or other measures designed to prevent scour or erosion shall be built as shown on the drawings or as directed by the designer. Any pitching of drains shall be undertaken in accordance with the requirements of Clause 27.8.

27.3.2 Construction of Open Drains

All open drains shall be maintained for the duration of the Contract. Care shall be exercised to avoid excavation below the required grade for the drains and any such excavation carried out below the

required grade shall be backfilled with suitable material and compacted to at least 90% of modified AASHTO density.

27.3.3 Construction of Concrete-lined Open Drains

Excavations for these drains shall be profiled and trimmed to the lines and levels specified to ensure the accurate construction of the concrete linings. The trimmed surface shall be compacted to at least 93% modified AASHTO density to a depth of at least 150 mm.

Where excavations are in rock, overbreak shall be backfilled with mass concrete.

27.3.4 Construction of Articulating Concrete Block (ACB) System-lined Open Drains

27.3.4.1 Materials

The ACB system shall be Armorflex® 180 or equivalent. The blocks shall be laid by hand unless otherwise directed by the designer.

Each block shall be factory produced, from compressed concrete, with vertical holes and two horizontal cable ducts. Concrete used in the manufacture of the blocks shall have a 28 day compressive strength of not less than 30 MPa.

Outside dimensions in millimetres shall be 340 x 300 x 110 high. Each block shall have a mass of approximately 17.1 kg. The interlocked blocks shall have a unit mass of 180 kg/m^3.

Galvanized wire of 3mm diameter shall be used. The wires are to run at right angles to the direction of flow.

27.3.4.2 Preparation of exposed surfaces

The base of the canal will be prepared in accordance with the lines indicated on the detail drawings. The finished level shall not deviate more than 25 mm on a 3 m straight edge. In cut the trimmed excavation must be to line and level, fill must be compacted to 90% Mod. AASHTO density before being trimmed to line and level. The surface should be like a grader type finish, free from protruding roots, tree stumps, rocks, etc.

27.3.4.3 Geotextile

Industex S135 or equivalent shall be placed on the prepared surface to the lines shown on the drawings. Overlaps must at least be 250 mm.

27.3.4.4 Laying of interlocking blocks

After the geotextile has been laid, the blocks shall be laid by a half bond interlocking pattern. The cable ducts will be at right angles to the direction of water flow of the canal and the shorter dimension of the blocks shall be in the direction of flow. The minimum number of blocks should be cut along

corners and bends. Laying shall always commence on the floor of the canal. Once a grid of blocks has been laid, the wires shall be fed through the cable ducts. The wires shall be of 3.1 mm diameter hot dipped galvanized fencing wire. The length of the wires shall be sufficient to allow the exposed ends to be effectively jointed. The wires must be jointed by twisting the ends neatly for a twisted stretch of minimum 100 mm. The finished level of the blocks may not deviate more than 25 mm on a 3 m straight edge. No individual block may protrude more than 10 mm proud of any adjacent blocks.

27.3.4.5 Anchoring

Anchoring by means of Y-fencing standards:
The blocks shall be anchored in a 2 m grid with 1.4 m long Y-fencing standards driven into the ground.

Anchoring with anchor beam:
The concrete shall 400 mm deep and the beam shall be at least 400 mm deep and 250 mm wide. The concrete shall have a 28 day strength of at least 20 MPa. R8 U-bars at 340 mm centres shall be cast into the beam.

Anchoring along the sides of the canal:
Anchoring along the top edge of the ACB lining shall be according to details on the drawings.

Construction joints shall be provided at 5 m centres along anchor and other concrete beams.

27.3.4.6 Backfilling and grassing

As soon as the blocks have been laid, wired up and the anchors provided, the open cells and joint areas shall be filled with topsoil and the area seeded. Fertilizer shall be mixed into the soil before backfilling. Immediately after hydroseeding the hydroseeded area shall be watered.

27.3.4.7 Maintenance

The grass shall be watered and maintained during the duration of the Contract, including and the control of weeds and alien invasive plants. Damaged areas shall be repaired.

27.3.5 Construction of Banks

Mitre banks and catchwater banks shall be constructed of suitable soil or gravel obtained from open-drain excavations or, if no suitable material can be obtained from that source, from suitable alternative sources, and be placed in such a way that the water will flow on the natural ground and against the bank.

The banks shall be compacted to at least 90% of modified AASHTO density in layers not exceeding 150 mm in thickness, true to the lines, levels and cross-sections, shown on the drawings or directed by the designer.

Mitre banks may also be constructed of hand-packed stone, provided that the gaps are filled with suitable cohesive soil.

27.4 SUBSURFACE DRAINS

27.4.1 General

All subsurface drains shall be designed and constructed as shown on the drawings or where instructed by the designer. They may be located to drain underground water, which could endanger the stability or affect the serviceability of the Works.

They may be installed in herringbone fashion, with side collectors, when flow is along the Works or in any other necessary pattern that will drain surplus water away from the Works. They may also be installed below the invert of side drains to intercept cross flows. The subsurface drains shall be graded to discharge into the surface drainage system, away from the Works, or if necessary, into plain pipes which in turn will drain away from the Works via suitable outlets as indicated on the drawings or directed by the designer.

The subsurface drains shall consist of a combination of un-lined trenches, with natural permeable filter material and perforated drainage pipes or a combination geotextile lined trenches with crushed stone filter material and perforated drainage pipes.

27.4.2 Materials for Subsurface Drains

27.4.2.1 Pipes

Pipes for subsurface drains shall be one of the following types as dictated by the position of installation and as indicated on the drawings:

a) Corrugated single wall perforated pipes, manufactured from HDPE (High Density Polyethylene);
b) Double wall, corrugated outer wall and smooth inner wall, perforated pipes manufactured from HDPE compliant with BS EN 61386-24:2010prior to perforation;
c) Perforated slotted uPVC pipes complying with SANS 791, Class 51 (normal duty); or
d) Perforated slotted uPVC pipes complying with SANS 791, Class 34 (heavy duty).

The arrangements or coverage of the slots shall not proceed beyond the top 240 degrees of the pipe and the flow channel at the invert of the pipe shall not be less than 120 degrees.
The nominal slot width shall be between 1.4 mm and 2.0 mm, and the minimum area of drainage shall be 3 360 mm^2 for 110 mm nominal OD pipes and 5 000 mm^2 for 160 mm nominal OD pipes.

Un-perforated pipes required for conveying ground water from the subsurface drainage system to the point of discharge, shall be un-perforated pipes of the types specified above as shown on the drawings or as directed by the designer.

27.4.2.2 Natural Permeable Filter Material

Natural permeable filter materials for subsoil drainage shall consist of sand of suitable gradings.

Natural permeable materials shall conform to the following requirements:

- Sand shall be clean, hard sand obtained from approved sources;
- The sand shall comply with the requirements of SANS 1083, Table 27/1: Sand for concrete, and shall be either coarse, medium or fine grade as specified; and
- The nominal maximum particle size for the various grades shall be as shown in Table 27/1.

TABLE 27/1
NATURAL PERMEABLE MATERIALS: SAND

GRADE	NOMINAL MAXIMUM PARTICLE SIZE (mm)
Coarse	4.75
Medium	2.00
Fine	0.20

In the case of any sand, not more than 5% of the material shall pass through a 0.075 mm sieve.

27.4.2.3 Crushed Stone

Crushed stone shall comply with the requirements given in SANS 1083, Table 5: Stone for Concrete, and shall be either coarse (19.0 mm nominal size) or fine (13.2 mm nominal size) as specified. The aggregate shall be evenly graded. The aggregate crushing value of the stone shall not exceed 30 when tested in accordance with TMH1 method B1.

In the case of sand not more than 5% of the material shall pass through the 0.075 mm sieve.

27.4.2.4 Synthetic-fibre Filter Fabric (Geotextile)

The synthetic-fibre filter fabric or geotextile shall be of the nonwoven continuous filament needle punched polyester type.

The synthetic-fibre filter fabric is classified according to the mechanical properties thereof, viz its penetration load, puncture resistance and the minimum water percolation rate as measured in the permeability test. Table 27/2 shall be used for determining the grade of a synthetic-fibre filter fabric.

TABLE 27/2
GRADE CLASSIFICATIONS OF SYNTHETIC-FIBRE FILTER FABRIC

PROPERTY	GRADE			TEST METHOD
	1	2	3	
Penetration load (minimum), N	3900	2500	1600	SANS 12224
Puncture resistance (maximum), mm	14	26	32	EN ISO 13433
Water percolation (minimum), ℓ/m²/s	70	70	145	SANS 10221

Notes: The standard atmosphere for testing and the preconditioning atmosphere for all synthetic-fibre filter fabric tests (SANS tests and other) shall have a relative humidity falling within the range of 10 to 50 per cent and a temperature within the range of 15°C to 50°C.

The resistance of a synthetic-fibre filter fabric to puncture is the average diameter of the hole formed when a 45° cone with a mass of 1 kg is dropped through 500 mm on to the synthetic-fibre filter fabric fixed in the holding device. The test method and parameters shall be in accordance with EN ISO 13443.

The synthetic-fibre filter fabric shall withstand the level of aggressiveness of the soil and ground water given below without significant loss of its strength and hydraulic properties during its design life of 25 years:

- Soil and ground water with a pH in the range of 4 to 12 (pH to be determined by Method A20, TMH1, 1986); and
- Soil (as paste) and ground water containing salts with a conductance of up to 1.0 S/m (conductivity to be determined by Method A21T, TMH1, 1986).

The synthetic-fibre filter fabric shall maintain at least 80% of its original strength after direct exposure to sunlight of 1 500 hours.

The synthetic-fibre filter fabric shall be entirely rot-proof and shall not support the growth of algae.

The synthetic-fibre filter fabric required shall satisfy the criteria for grade 1, 2 or 3 synthetic-fibre filter fabric as specified on the drawings.

27.4.3 Construction of Subsurface Drainage System

27.4.3.1 Construction with Natural Permeable Material (No Geotextile Lining)

Trench excavations shall be to the dimensions and gradients as shown on the drawings or as directed by the designer.

A layer of natural permeable material of the class and thickness as shown on the drawings shall be placed on the bottom of the trench to the required grade.

Pipes shall then be laid and firmly bedded on the natural permeable material in accordance with the manufacturers' specification, with perforations at the top. Thereafter the trench shall be further backfilled with natural permeable material. The permeable material shall be lightly compacted and finished to the required level. Further layers of finer natural permeable material shall then be placed, lightly compacted and finished to an even surface. The remainder of the trench, if any, shall be backfilled with suitable impermeable material and in layers not exceeding 200 mm and compacted to a minimum of 90% of modified AASHTO density or at least to the same density as the surrounding material. The trench shall be specially protected against the ingress of water until the impermeable layer has been completed.

Natural permeable material shall be placed in layers of not more than 300 mm at a time and be lightly compacted. The total thickness of each type of natural permeable material shall be carefully controlled, and when placing thinner layers, suitable spacers shall be used. When placing successive layers the lower layers shall not be walked on and as far as possible shall not be disturbed. Care shall be taken to prevent the contamination of natural permeable material during construction of the subsurface drains and all permeable material contaminated by soil or silt shall be removed and replaced by the Contractor.

Any section of a subsurface drain constructed from pipes without perforation or slots shall be backfilled with impermeable backfill material as described above.

27.4.3.2 Construction with Synthetic-fibre Filter Fabric Lining (Geotextile)

Where specified on the drawings or as directed by the designer, the trench shall be lined with geotextile and secured flush against the trench sides.

A layer of crushed stone of the nominal size and thickness as shown on the drawings shall be placed on the bottom of the trench and be lightly tamped and finished to the required grade.

Pipes shall then be laid and firmly bedded on the crushed stone in accordance with the manufacturers' specification, with perforations at the top. Thereafter the trench shall be further backfilled with crushed stone to the height above the pipes as shown on the drawings or as directed by the designer. The geotextile shall then be folded back to complete the top of the box forming the drain. The geotextile shall overlap by at least 300 mm.

27.4.3.3 Concrete Encasement of Drain Pipes

Where drain pipes are to be encased in concrete, the pipes shall be laid on supports comprising in-situ concrete cradles of the same concrete strength as the encasement concrete. Care shall be taken to prevent flotation or displacement of the pipes during concreting.

27.4.3.4 Caps and Head Walls

The higher end of subsurface drain pipes shall be sealed off with a loose concrete cap or end caps of the same material as the pipe, where available.

At the lower end the pipe shall be built into a concrete head wall, providing a positive outlet or connected to stormwater pipes or culverts.

27.4.4 Testing of Subsurface Drains

All subsurface pipes shall be tested, once earthworks or other works are completed, by flushing with clean water and shall be cleaned if blocked.

27.5 PREFABRICATED CULVERTS

27.5.1 General

Stormwater runoff originating from open drains, slopes and streams shall be directed using concrete pipe, portal or rectangular culverts and shall be constructed at the locations and to the sizes, shapes and dimensions shown on the drawings or as directed by the designer.

27.5.2 Materials

27.5.2.1 Culvert Units

The prefabricated culvert units shall be factory produced by a reputable manufacturer and shall comply with the following requirements:

(a) Precast Concrete Pipe Culvert Units

Concrete pipe units shall comply with the requirements of SANS 677. Concrete pipes shall be of the spigot and socket type using the rolling rubber ring principle or of the in-the-wall-joint type using the sliding rubber ring principle.

(b) Portal and Rectangular Precast Concrete Culvert Units

Rectangular or ribbed skew haunch portal precast concrete culvert units shall comply with the requirements of SANS 986.

Note: No precast concrete culvert units, as specified in a) or b) above, shall be transported and delivered to Site within 14 days of being cast.

27.5.2.2 Bedding Material

Bedding material and fill blanket material for pipe culverts shall be as specified in Section 15 for Type A bedding.

27.5.2.3 Skewed Ends

Where culverts are to be constructed at a skew angle of more than 20°, the culvert units at the inlet and outlet of the culvert shall be supplied with skew ends. Skewed units shall be supplied by the manufacturer and cutting of skew ends on Site shall only be allowed if authorised by the Engineer.

Portal and rectangular units shall be provided with skewed ends constructed from cast in-situ reinforced concrete.

27.5.2.4 Defects

All broken, bent, chipped, cracked, dented, or otherwise damaged units shall be repaired to the Engineer's satisfaction or, where this is not possible, be removed and replaced with undamaged units.

27.5.2.5 Joint Filler

Joint fillers shall be, high density, cross linked, closed cell expanded Polyethylene as specified in Section 20.

27.5.2.6 Sealants

Sealants shall be 1-part, moisture cured, high mechanical resistant polyurethane sealant as specified in Section 20.

27.5.2.7 Waterproof Adhesive Tape

Waterproof adhesive tape for sealing joints shall be 200 mm wide burlap, 340 g/m^2,pre-impregnated with a bituminous emulsion; or

200 mm wide Geotextile Grade 3 (Table 27/2) pre-impregnated with a cementitious slurry consisting of the following mix:

- Synthetic Polymer Latex: Water - 1 : 1 (Emulsion).
- Water (Emulsion) : Cement ratio - 0.8 and Cement : Sand ratio - 1 : 1

27.5.3 Construction Methods

Prefabricated culverts shall be constructed under either:

a) “Trench conditions”, where the units are laid in a trench excavated below existing ground level or in a trench excavated in previously constructed fill and, if necessary, subbase layers; or

b) “Embankment conditions”, where the units are laid approximately on the existing ground surface and the fill is then constructed on either side and over the culvert.

Small diameter concrete pipe and small portal culverts shall normally be constructed under trench conditions.

Large diameter concrete pipe and large portal culverts shall normally be constructed under embankment conditions.

27.5.4 Bedding and Laying of Prefabricated Culverts

27.5.4.1 Concrete Pipe Culverts

Concrete pipe culverts shall be laid on Class A or B bedding as shown on the drawings or as directed by the designer. Spigot and socket or in-the-wall joint type pipes shall be laid with the spigot ends pointing downstream. The inside of the culverts shall be smooth with no displaced joints.

(a) Class A Bedding

The pipe shall be laid so that the lowest part of the pipe rests on concrete of thickness 0.25D and the concrete extends upwards on either side of the pipe to a height of 0.25D, where D is the internal diameter of the pipe. The thickness of the concrete shall be a minimum of 100 mm and a maximum of 300 mm for trenches in soil and minimum 50 mm for trenches in hard rock.

The concrete shall be Class 20/19 F30 unless otherwise shown on the drawings. During concreting, pipes shall be supported on suitably shaped temporary concrete cradles of the same class as the bedding concrete. Care shall be taken to prevent flotation or displacement of pipes during concreting.

A fill blanket of Type SC1 material (Section 15) shall extend upwards on either side of the pipe from the top of the bedding to 300mm above the top of the pipe.

(b) Class B Bedding

The pipe shall be bedded on a layer of compacted Type SC1 bedding material of thickness 0.25D not less than 100 mm and not exceeding 200 mm. The granular material shall extend to a height of 0.50D. Joint holes shall be formed in the trench bottom for pipe sockets and couplings. A fill blanket of Type SC1 material shall extend upwards on either side of the pipe from the top of the bedding to 300 mm above the top of the pipe.

(c) Rock Foundation

Where rock, or other hard material is encountered on the bottom of excavations, construction of pipes on Class B bedding shall proceed as follows:

- The loose material and rock pinnacles shall be removed and replaced with a levelling layer of sand or Type SC1 bedding material compacted to 93% modified AASHTO density. and
- Class B bedding shall then be prepared and placed.

(d) Concrete Encasing

Pipes shall be fully encased in Class 20/13 F30 concrete to the dimensions as shown on the drawings or as instructed by the designer. Temporary supports shall be provided near the pipe ends to support the pipes during placing of the concrete. The concrete shall be placed in such a way that all spaces under the pipe are completely filled. Poker vibrators shall be used to ensure that all spaces under and around the pipes are properly filled with concrete.

Concrete casing shall have a flexible joint at each pipe joint formed using a joint filler in accordance with Clause 27.5.2.

27.5.4.2 Portal and Rectangular Culverts

(a) Cast In-situ Floor Slabs

Cast in-situ floor slabs shall be constructed to the dimensions and at the locations as shown on the drawings or as directed by the designer. They shall be reinforced with steel reinforcement as detailed on the drawings.

Joints as detailed on the drawings shall be formed in the floor slabs, and between the floor slabs and the inlet and outlet structures.

(b) Placing the Portal Portion of Culverts

The upper portion of portal and rectangular culverts shall be placed accurately on the floor slabs, with a thin layer of 1 cement : 4 sand mortar between the contact surfaces to ensure a firm and uniform support.

The units shall be butted end to end with butt joints and the joints shall be sealed with two layers of waterproof adhesive tape, as per Clause 27.5.2.7, placed symmetrically over the joint. The strip of waterproof adhesive tape shall be at least 200 mm wide.

In the case where two or more culverts are placed side by side to form a multi-barrel culvert, the space between the culverts shall be filled with Class 20/19 F30 concrete up to the level of the top of the culverts.

27.5.4.3 General

Construction of culverts shall begin at the lower end, the position of which shall be fixed as shown on the drawings or as directed by the designer. The position of the other end of the culvert shall normally be determined by the end of the last whole unit, the top of which breaks through the fill slope. However, in the case of skew culverts, or culverts with a cover of less than 0.5 m at the shoulder, the designer may order that the end unit be cut to the length and skew required.

Any units which deform or crack or which are not constructed to the required lines, levels and grades, or which become displaced during the duration of the Contract, shall be removed and replaced by the Contractor.

Precast units shall be lifted and handled by means of lifting devices only. Lifting holes shall be caulked with a suitable mortar after the units have been installed. The Contractor shall exercise due care not to damage, overstress or displace any prefabricated culverts with his own traffic or compaction equipment.

Where loads in excess of those prescribed for Class 100D culverts are likely to pass over completed culverts, the Contractor shall provide additional cover over the culverts so as to ensure that the design stresses of the culverts are not exceeded. If the Contractor is required to supply and install culverts at a slope of more than 1:4, the work shall be carried out as specified in Clause 27.5.5.

27.5.5 Culverts on Steep Gradients

Where culverts are constructed on gradients exceeding 1 in 4, they shall be referred to as “inclined culverts”. Particular care shall be taken to protect excavations against stormwater damage and the trenches shall be excavated to firm ground. The trenches shall be backfilled with selected gravel or concrete if it is necessary to over-excavate in order to obtain a firm floor.

After first completing the outlet structure, the culvert units shall be laid in the normal manner, starting from the lower end and placing successive units firmly against each other to prevent subsequent movement. The lower unit shall be securely cast into the outlet structure.

Thrust and anchor blocks shall be constructed according to the drawings or as directed by the designer to suit the site conditions.
Backfilling of trenches shall be undertaken in horizontal layers, starting at the lower end.

27.5.6 Stormwater Pipes, and other Closed Conduits

The requirements set out for culverts in this Section, shall apply mutatis mutandis to the construction of stormwater pipes or any other closed conduits intended for drainage.

27.6 DRAINAGE STRUCTURES

27.6.1 General

Drainage collecting structures such as manholes, catch-pits and other inlet structures and dispersion structures such as chutes, down pipes and other outlet structures shall be constructed at the locations and to the sizes, shapes and dimensions shown on the drawings or as directed by the designer.

27.6.2 Materials

27.6.2.1 Concrete and Reinforcement

All formwork, reinforcement and concrete shall comply with the provisions of Section 20 – Concrete Works (Structural).

27.6.2.2 Precast Concrete Blocks in Outlet Structures

Where shown on the drawings or instructed by the designer, the Contractor shall supply and install in drainage outlet structures, precast reinforced concrete flow dissipater blocks of Class 30/19 F50 concrete of and sizes shown on the drawings.

27.6.3 Construction

27.6.3.1 General

The methods, procedures, etc., to be used shall be strictly in accordance with the requirements of Section 20 - Concrete Works (Structural).

The form of manhole construction to be adopted is to be compatible with the finished depth of the manhole, the size of the largest pipe in the invert and the location of the manhole.

27.6.3.2 Concrete Cast In-situ Manholes

Concrete cast in-situ manholes shall be constructed in reinforced concrete in accordance with the drawings or as directed by the designer. The inlet and outlet pipes shall be cast into the manhole walls but shall not protrude into the manhole by more than 150 mm. Where necessary the pipes shall be bevelled to suit the entrance and exit angles.

Where manholes are deeper than 1.0 m, galvanised step-irons shall be cast into the walls at 300 mm staggered vertical intervals. Manhole covers shall be of the type shown on the drawings.

27.6.3.3 Inlet and Outlet Structures

Concrete cast in-situ inlet and outlet structures shall be cast in accordance with the drawings or as directed by the designer. Where specified, a reinforced concrete apron with flow dissipaters shall be constructed at the outlets of culverts, stormwater sewers and pipe chutes as shown on the drawings or as directed by the designer.

27.6.3.4 Screeding to Fall

Screeds to the invert of drainage structures shall be of the pre-scribed mix with wood-floated finish in accordance with Section 20.

27.7 DOWNPIPES

27.7.1 Materials

Concrete, formwork and reinforcement shall comply with the requirements of Section 20 - Concrete Works (Structural).

The materials to be used shall be as shown on the drawings. The Contractor shall confirm and submit to the Engineer at least 28 days prior to the commencement of the specific Section of the Works, samples, specification and performance data, as applicable of all the products he intends to use.

27.7.2 Construction

The installation of the down pipes and discharge of these pipes into the surface or sub-surface stormwater drainage shall be as indicated on the drawings or as instructed by the designer.

27.8 STONEWORK AND EROSION PROTECTION

27.8.1 General

Stonework and other erosion protection measures shall be used to prevent scour and erosion of watercourses, cuts, fills, drains and culvert inlet and outlet areas as shown on the drawings or as directed by the designer.

The construction of and the materials used in the construction of reno mattresses, as shown on the drawings or as directed by the designer, shall comply with all the relevant requirements of Section 21 - Gabions and Reno Mattress Structures.

27.8.2 Materials

Stone for pitching shall be clean, hard, durable, unweathered boulders or rock fragments with no stone less than 150 mm in minimum dimension except that smaller pieces or spalls may be used for filling spaces between the larger stones. Rocks or stone shall be of such a shape that a stable protection structure of the required thickness is formed. Rounded boulders or cobbles shall not be used on slopes steeper than 2:1 unless grouted. The specific gravity of the stone shall not be less than 2.5.

Stone for rip-rap shall be uniformly graded, dense, hard rock fragments or stone, not susceptible to disintegration or excessive weathering (which includes loss of mass, strength or the development of cracks) on exposure to the atmosphere or water. Rip-rap shall be abrasion resistant and shall withstand the stresses involved in supplying, dumping, spreading and compaction in place. It shall be free from soft material such as sand, clay, shale or organic material and shall not contain an excessive amount of elongated stone. Rip-rap material shall contain no deleterious matter such as oil, grease, chemicals or cement.

The stone shall be obtained from essential excavations.

The grading of rip-rap stone shall fall within the grading limits given in Table 27/3.

TABLE 27/3
LIMITS FOR RIP-RAP

RANGE OF STONE SIZE (IN TERMS OF D_{50} STONE SIZE)	FRACTION OF TOTAL WEIGHT SMALLER THAN THE GIVEN SIZE (%)
1.50 – 2.00 D_{50}	100
1.30 – 180 D_{50}	85
1.00 – 1.50 D_{50}	50
0.30 – 0.50 D_{50}	15

The D_{50} stone size for rip-rap in various sections of the Works shall be as specified on the drawings.

27.8.3 Construction

27.8.3.1 Stone Pitching

(a) Plain Stone Pitching

The area shall be prepared by excavating, shaping and trimming to accommodate the stonework and shall be thoroughly compacted by hand ramming to minimise subsequent settlement. A trench shall be excavated along the toe of any slope to be pitched or along the unprotected edge of the pitching in the beds of streams. One of the following two methods for the laying of stone shall be followed:

(i) Method 1

Commencing at the bottom of the trench, the stone shall be laid and firmly bedded into the slope and against adjoining stones. The stones shall be laid with their longitudinal axes at right angles to the slope and with their surfaces in contact. The stones shall be rammed well into the bank and surface to be protected and the spaces between the larger stones shall be filled with fragments of pitching stone securely rammed into place. Placing of rock by dumping shall not be allowed.

(ii) Method 2

The technique and requirements laid down in Method 1 shall apply to Method 2 except for the following aspects:

a) No small stones or spalls shall be used to fill in spaces between larger stones.

b) Simultaneously with placing of stones, topsoil shall be introduced between individual stones and shall be sufficiently rammed so as to provide a firm bonded construction. The topsoil shall be provided to the full depth of the stone pitching at any point.

c) Rooted grass or grass tufts shall then be planted in the topsoil between the stones and be given copious initial watering. Thereafter it shall be watered at regular intervals until the grass is established.

The finished surface of the pitching shall present an even, tight and neat appearance with no stones varying by more than 25 mm from specified surface grades or lines. The thickness of the pitching, measured at right angles to the surface, shall not be less than 150 mm.

(b) Grouted Stone Pitching

This work shall be undertaken in accordance with all the requirements specified for plain pitching in Clause 27.8.3.1 a) above, except that the stones shall be individually set in a bed of cement mortar composed of 1 part cement and 3 parts sand. Before the mortar is applied, the surfaces of the stones shall be thoroughly cleaned of adhering dirt and clay and then moistened. The mortar shall be placed in a continuous operation for any day's run at any one location. The mortar shall penetrate to immediately below the top of the pitching surface to ensure that each stone is completely surrounded, other than the surface, by a layer of mortar.

After the mortar has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured with wet sacking or other wet cover for a period of not less than 4 days after grouting and shall not be subjected to loading until adequate strength has developed. Where required, weep holes shall be formed in the pitching.

(c) Grouted Rockfill

This work shall be undertaken in accordance with the requirements of Clause 27.8.3.1 b) when rockfill is to be fully embedded in cement mortar.

27.8.3.2 Rip-rap

(a) General

Rip-rap shall consist of a course or courses of selected rock placed on bank slopes and toes, river and streambeds and other localities where protection of this type may be required. The grading, minimum dimensions and mass of the rock shall be as specified on the drawings.

The surface of areas to receive rip-rap shall be neatly trimmed to line and level and all loose material compacted. The perimeters of rip-rap shall be protected by the construction of either rock toes, rock-filled trenches, gabions, reno mattresses, walls or other structures, as may be required.

Perimeter trenches shall normally be backfilled with rock of the same size and quality as used in the construction of the rip-rap it adjoins, but any cavities shall be filled with smaller material and the whole backfill shall be well compacted.

(b) Dumped Rip-rap

Dumped rip-rap shall be constructed by dumping the stone on the prepared surfaces, spreading it by means of bulldozers or other suitable earth-moving equipment and trimming it to the required lines and levels. Rip-rap shall be placed in a manner to ensure that the larger rock fragments are uniformly distributed and the smaller rock fragments serve to fill the spaces between the larger rock fragments in such a manner as will result in well keyed, densely placed, uniform layers of rip-rap of the specified thickness. The critical mass of stone used shall be as specified on the drawings.

(c) Rip-rap Slope Protection

Where rip-rap protection is required on slopes which are too steep to allow the dumped method b) above to be used, the rip-rap shall be placed in layers concurrently with the construction of the fill. The rip-rap shall be placed in a manner to ensure that the larger fragments are uniformly distributed and the smaller fragments fill the spaces between the larger fragments forming well keyed densely placed, uniform layers of rip-rap of the specified thickness. Hand trimming will be required only to the extent necessary to achieve a well keyed surface. Where shown on the drawings or instructed by the designer, synthetic-fibre filter fabric (Grade 1) shall be placed between the rip-rap and the fill to prevent the migration of fine material.

(d) Filter Fabric for Rip-rap

When the use of synthetic-fibre filter fabric is required, the material shall be placed on the prepared surface. The overlap between adjacent sheets shall be 500 mm. Care shall be taken not to damage the filter fabric when placing subsequent layers, nor to expose the filter fabric to the sun for periods longer than necessary before covering up.

(e) Graded Natural Filter for Rip-rap

When the use of a graded natural filter is required, the material shall be placed on the prepared surface to the thickness specified on the drawings or instructed by the designer. Care shall be taken not to disturb this layer when placing the rip-rap. The grading of the natural filter, which shall be a natural gravel or crushed stone, shall be given on the drawings.

27.8.3.3 Masonry Walls for Drainage and Road Works

Masonry walls shall be constructed with stones set in cement mortar as indicated on the drawings. The minimum mass of stone shall be 10 kg. The minimum dimension of stone shall be 75 mm. A foundation trench shall be excavated down to rock or to material of adequate bearing capacity and the minimum depth shall be 300 mm below ground level. Large selected stones shall be used in the foundation layer. Flat and stratified stones shall be laid with the flat surface in the horizontal plane. Stones shall be individually placed to break joints and to provide a minimum of voids.

The stones shall be wetted and set in 3 sand to 1 cement mortar. Exposed stones on the wall faces shall be cleaned of mortar by washing or wire brushing. The mortar shall be flush pointed. The top and ends of the wall shall be neatly finished with selected coping stones.

Weep holes shall be provided as instructed and shall be cleaned of mortar and any other clogging material that may have entered during construction. The walling shall be protected from the elements and be kept moist for a minimum period of 4 days after completion.

27.9 TRIMMING AND CLEARING UP ON COMPLETION

After completion of construction all areas affected by the Contractor's operations shall be finished off and cleaned up, and all rock larger than 75 mm in maximum dimension, shall be removed and disposed of.

All intersecting earthwork slopes shall be neatly rounded. Drains shall be cleared of debris and obstructions, and any excess earth, debris or other waste material shall be removed to spoil or shaped and trimmed.

All loose stones, dead vegetation, or other waste matter exposed on fill or excavation slopes which are liable to become loosened and fall into drains shall be removed.
All parts of the work and adjacent ground shall be left in a neat and presentable condition to the satisfaction of the Engineer.

The rehabilitation of all disturbed areas shall be in accordance with Section 47 – Landscaping and Rehabilitation.

27.10 MAINTENANCE OF DRAINAGE WORKS

Up to the issuing of the Taking Over Certificate the Contractor shall regularly inspect and clear in all drainage works the rubbish, sediment run-off, waste, weed growth or any other material liable to interfere with the correct operation of the system.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 28

MECHANICAL GENERAL

TCTA MODULAR STANDARD

SECTION 28
MECHANICAL GENERAL

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SECTION 28

MECHANICAL GENERAL

28.1 SCOPE

This Section deals with the general requirements for mechanical installations and shall be read in conjunction with Sections 29 up to and including 37 as well as Section 48. Any particular requirement stated in those Sections shall take precedence over Section 28.

28.2 REFERENCES

When reference is made to a published national of international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

Plant, materials and operational methods shall, in order of preference, comply with the relevant SANS, SABS, ISO, BSS, DIN or equivalent American Standard whether prescribed or not.

The Contractor shall comply with OHSAct 85 of 1993, Construction Regulation 2014, Construction Regulation 11 - Structures, General Safety Regulation 9 - Welding, Electrical machinery Regulations, Installation of electrical boards and cabling.

28.3 DESIGN

28.3.1 General

a) The design shall be in accordance with best practice and shall be such as will facilitate operation, inspection, cleaning, repainting, lubrication, maintenance and repair to ensure the highest reliability under all operating service conditions.

b) The Contractor's design calculations shall be submitted to the Engineer with the appropriate drawings for review.

c) Generally, the design shall be such as to provide the maximum reliability under all conditions of service, coupled with safety and convenience of operation and maintenance under all conditions at the Site.

d) The design dimensions and materials of all parts shall be suitable for the specified service and be such that the stresses to which they may be subjected to shall not render them liable to buckling, breaking or excessive wear. The arrangements and details shall be simple and robust.

e) All moving parts shall work silently and be readily accessible for removal, maintenance and repair. All parts shall be designed, proportioned and supported so as to withstand, without undue deflection or deformation, the forces which may be applied to them.

f) Special measures shall be taken to prevent malfunction due to corrosion, to minimise risk of fire and to prevent ingress of dust, dirt, moisture and vermin.

g) Water abstracted from natural sources will contain coarse solids in suspension, floating debris, a degree of turbidity, sediment and grit especially after heavy flood run-off. Water may also be corrosive or support bacterial corrosive action. The Plant shall be designed and manufactured with due consideration of the properties of the water conveyed and/or treated, and to its satisfactory operation, inspection and maintenance for water with these properties.

28.3.2 Vibration and Design Loads

a) Special care shall be taken to ensure that all items of Plant are free of harmful vibration and to ensure that resonance of any part does not occur as a result of harmonics when it is installed in its final position.

b) All fastenings on Plant which may be at risk of vibration under certain combinations of loadings and operating conditions, shall be designed by means of lock washers or by other means specified by the designer, to prevent loosening due to vibration or other any cause.

c) Design loads and load cases shall be those set out in DIN 19704/5: Hydraulic Steel Structures, except that:

i) Seismic conditions shall be considered, with the simultaneous application to all parts of the Works of a seismic event having a vertical acceleration of 0.06 g and a horizontal acceleration of 0.08 g (hereinafter referred to as the "Design Basis Earthquake" or DBE) applied in the most adverse combination and direction;

ii) All components of the Plant in question shall, after the seismic event, remain broadly operational without the need for other than minor adjustment. In particular, permanently submerged components (such as gate guides) shall not be distorted to such an extent as to prejudice correct operation of the gates after the most adverse combination of gate position and vertical and/or horizontal seismically induced forces.

iii) In respect of the design of gates (and associated hoist and hoist gantry) the provisions of ii) above shall be applied under the following conditions:

- Gates closed and subject to the specified maximum water levels; and
- Gates partially open in still water or in air at any vertical position.

iv) In respect of the design of other hoists and cranes the provisions of ii) above shall be applied under fully loaded conditions at any vertical position.

28.3.3 Permissible Stresses

28.3.3.1 General

The Plant shall be designed such that no part of the Works under any loading condition shall impose any stress greater than those set out below on or in any 30 MPa concrete work unless a lower value is specified by the designer:

- For bedded bearing stress: 12 MPa
- For shearing stress: 1.7 MPa

No tensile stress shall be allowed in concrete.

Under the most severe operating and/or erection condition, stresses in castings and forgings expressed as percentages of tensile strength shall not exceed the figures set out in the table below.

TABLE 28/1
MAXIMUM STRESS PERCENTAGES

MATERIAL	TENSION	COMPRESSION	SHEAR
Grey cast iron	10%	20%	6%
Nodular cast iron	20%	20%	12%
Carbon or low alloy cast steel	20%	20%	16%
High alloy cast steel	20%	20%	16%
Carbon and high alloy forgings	25%	25%	20%

The value of tensile strength to which the tabulated percentages shall be applied shall be the tensile strength (as defined in BS EN ISO 6892-1) of the proposed grade of metal as guaranteed by the supplier of the metal on the basis of tests carried out in accordance with BS EN ISO 6892-1.

2.8.3.3.2 Gates and Valves

All structural steel parts shall be manufactured from steel conforming to SANS 1431, Grade 300W, or equivalent standard.

Permissible stresses for this steel, as well as for 3CR12, shall be determined according to SANS 10162: “The Structural Use of Steel”. These stresses are to be multiplied by the following minimum coefficients to allow for indeterminate factors:

- Valves: 0.85
- Sliding gates: 0.90

When calculating the stresses including transient and earthquake forces, the primary stresses shall not exceed 80% of the yield stress of the material used and where secondary stresses are included the stress shall not exceed 85% of the yield stress of the material used, unless a lower value is specified by the designer.

2.8.3.3.3 Linings

Unless a lower value is specified by the designer, the permissible working stresses for all steel linings and transitions shall not exceed those that are given in PD 5500. Where the proposed steel is BS EN 10028 a basic permissible working stress of 223 MPa shall be used. If steels other than the above are proposed the permissible working stresses shall be as obtained from PD 5500, but in this case special consideration must be given to the other requirements of PD 5500 regarding welding details, pre-heating, stress relieving, weld joint factor, handling, etc.

Radiographic inspection shall be done for 100 % of the longitudinal welds and where possible, of the circumferential welds including the joint between the circumferential welds and the adjacent longitudinal welds. In addition, all in-situ (field) welds shall be 100 % radiographically inspected. The joint factor to be used in design shall then be taken as 1.0 and the design is based on this factor.

28.4 DRAWINGS

28.4.1 Drawings Issued by the Engineer

The drawings issued as part of the Contract are not considered to be manufacturing drawings and any dimensions shown are provided to enable the Contractor to do his/her design and working drawings.

28.4.2 Contractor's Drawings

The Contractor shall submit the following drawings to the Engineer for review:

- Design
- Manufacturing (Workshop)
- Installation
- As-built

28.4.2.1 Concept Design Drawings

a) The Contractor shall submit concept design drawings for review by the Engineer before commencing with manufacturing drawings.

b) Concept drawings submitted by the Contractor shall give sufficient information to make a proper assessment of the Plant offered together with sufficient detail to enable the dimensions and general arrangement of the Plant to be determined. All the important parts shall be shown in detail, i.e. gate body, scaling arrangements, bearing arrangements, guides, wheels, etc.

c) Drawings shall include details of parts to be built into, and loads to be transferred to, the civil engineering works, routes and sizes of cabling, cable ducts or trunking, hydraulic pipework, description of erection methods, operating and control units, position indicators and details of connections to any other Plant.

d) Piping and Instrumentation Diagrams (P&ID) indicating the interface between piping, instrumentation, electrical and mechanical equipment with symbols complying with ISO standards.

e)

28.4.2.2 Manufacturing (Workshop) Drawings

a) Before commencing with fabrication, drawings in triplicate shall be submitted to the Engineer for review. These drawings shall cover the general arrangement, assembly and supporting detailed drawings of the Plant offered and their related ancillary Plant items.

b) The drawings shall provide complete information regarding thickness and types of material, finishing of surfaces, fixing and connections, standard parts, tolerances, clearances with regard to other machine parts or building faces and in general everything that may have a bearing on the satisfactory fabrication, erection and operation of the Plant shown on these drawings.

c) Electrical Plant wiring and or hydraulic diagrams for sub-assemblies such as distribution and control boards, as well as overall integrated cabling and wiring diagrams for the complete installation, shall be prepared and submitted in a similar fashion to these drawings.

d) Detailed Piping & Instrumentation Diagrams.

e) Priority shall be given to submitting drawings that affect the concrete or other construction work of a civil engineering nature. Those drawings shall detail in full, the necessary provisions to be made in the concrete or other supporting structure(s) for casting in of embedded parts and anchors for fixing of built-in parts and Plant.

f) All the foundation details and the positions and dimensions of all connecting rods, pockets, vent ducts, cable ducts, anchor bolt holes and similar items, as well as aligning, fixing, anchoring and second stage concrete requirements must be clearly indicated and detailed on these drawings with the general requirements for built-in parts.

g) The magnitudes and directions of all forces and loads, both static and dynamic, exerted by the Plant on the supporting concrete structure shall be clearly and fully detailed on the Contractor's drawings. Any special requirements to prevent transmitting possible vibrations must also be shown.

28.4.2.3 Installation Drawings

The installation drawings shall provide the necessary details including foundation details and anchor bolts.

28.4.2.4 As-built Drawings

As-built drawings shall contain general arrangements, assemblies, parts lists (including part numbers) and complete component details as well as wiring, hydraulic, piping and instrumentation diagrams. These items are required in draft form before the Tests on Completion can commence and in final form before Taking Over in terms of the Conditions of Contract.

28.5 MATERIALS

a) All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfection and selected for long life and minimum maintenance.

b) All parts subject to submergence or subject to relative movement shall be of corrosion-resistant metals. All parts in direct contact with various chemicals shall be completely resistant to corrosion and abrasion by those chemicals. All parts shall maintain their properties with minimum deterioration due to the passage of time, exposure to light or any other cause.

c) Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion potential is minimised or preferably eliminated by the use of standard isolating procedures.

d) All materials, supplies or articles used in the Plant shall be new products of recognised reputable manufacturers with established dealerships and/or agencies in the Republic of South Africa and subject to the acceptance of the Engineer.

e) The Contractor shall provide performance data, references to completed projects and any other relevant information together with samples of materials for review by the Engineer.

f) Tolerances and clearances shall be such to avoid vibration but all moving parts shall operate freely and shall be such that the risk of undue wear or jamming under load or on account of debris, temperature effects, encrustation or other causes is minimised.

g) The procedures for fabrication shall be as specified in Clause 4.3 of SANS 2001, Construction Works, Part CS1: Structural Steelwork subject to the specific requirements that all burrs shall be removed, flame cut edges dressed and sharp edges ground off to a radius of at least 2 mm and smoothed. Holes shall be drilled, not punched.

h) All similar items of Plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same type of materials as the originals and shall fit all similar items of Plant. Machinery fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

i) All Plant shall operate without harmful vibration and with minimum noise. All revolving parts shall be statically and dynamically balanced so that when running at all operating speeds and any load up to a maximum, there shall be no vibration due to lack of balance.

j) All parts which can be worn or damaged by dust shall be totally enclosed in a dust-proof housing.

k) Manufacturers of stainless steel items shall comply with the “Stainless Steel Good Housekeeping Rules” as issued by SASSDA.

l) The names of the manufacturers of Materials and Plant, together with performance reports, capacities, certified test reports and other significant information pertaining to such manufacturers, shall be furnished when requested by the Engineer.

28.6 STORAGE, HANDLING AND TRANSPORTATION

28.6.1 Assembly in Manufacturer’s Workshop

Excluding any deviation accepted by the Engineer, each machine, appliance or assembly of the Plant shall be completely assembled in the manufacturer’s workshops. Each part shall be identified so as to ensure the correct assembly of the parts when they are erected on Site. All adjustments and welding which may be made in the workshop shall be made so as to avoid as far as possible adjustments and welding on Site.

28.6.2 Numbering and Marking of Materials, Plant and Parts

Before dispatch to Site all Materials, Plant and parts shall be clearly numbered and marked to ensure the correct assembling, erection or storage thereof on Site. The numbers and marking shall be punched and/or painted so as to be clearly visible at the time of erection and assembly.

28.6.3 Packing for Transport and Storage

a) Plant sensitive to vibrations, such as electrical cabinets shall be additionally placed in “vibration proof” packaging material.

b) Satisfactory temporary end covers shall be provided for the protection of flanges, prepared ends of plain-ended pipes, specials and fittings, and threads.

c) In addition to the normal shipping and transport markings, all items and packages shall be clearly identified with at least the following information:

- Name and locality of the Project;
- Contract number;
- Component description; and

- Mass (gross and nett.)

d) Bolts and other small parts shall be sewn up in strong bags and crated. The bags shall be tagged using metallic tags and indicate the following information:

- Manufacturer's/supplier's identification and contract number;
- Part numbers;
- description of content;
- Sizes; and
- Quantities.

e) Where tapped holes are provided for lifting devices (such as eyebolts) the tapped holes shall be plugged with stainless steel socket head screws (the thread of which shall be covered with an anti-seize compound).

28.6.4 Storage

a) The Contractor shall ensure that during the period awaiting delivery to Site and or installation, all Plant, Plant items, Materials and parts are suitably stored in a safe place above ground and under cover (where necessary), and shall be protected against any damage by sand, dust, stormwater, moisture, weather conditions, insects, vermin or fungal growth.

b) The Contractor must provide a schedule for care and turning of the rotors of the pumps and motors and other preservation tasks that may be necessary.

c) Grass or other vegetation shall not be allowed to grow in the storage area within three (3) metres of the Works and Plant stored.

28.6.5 Handling during Loading, Off-loading and Installation

a) Care shall be taken to ensure the corrosion protection system is in not damaged and/or the parts are not overstressed. The materials shall at all times be handled with suitable equipment, employing stout, wide canvas or rubber-covered slings and wide padded skids designed to prevent damage to the exterior coating. Bare cables, chains, hooks, metal bars, or narrow skids shall not be allowed to come into contact with either the exterior coating or the interior lining of any item.

b) Coated Plant shall not be allowed to rest directly on the ground. The Contractor shall provide the necessary beams of timber and sawdust bags to support the Plant and components on soil, concrete or other hard surface and to separate them from each other during transportation and on Site.

28.7 STEELWORK

28.7.1 Minimum Thickness and Corrosion Allowance

a) Stainless steel and 3CR12 (except for that which is used for cladding), subject to a river water environment, and outdoor environment or an indoor environment, shall have a minimum thickness of 8 mm and 6 mm respectively.

b) All other steel, with the exception of machinery house claddings, gear covers, etc., subject to an outdoor environment and subject to corrosion (even though painted on both faces or one face only), shall have minimum thickness of 6 mm.

c) Steelwork (except stainless steel) shall be thicker, by not less than 0.8 mm for each exposed face, than that required when calculated in accordance with this Section to resist the applied loads, to allow for corrosion.

28.7.2 Steel for Fabricated Construction

a) Mild steel for welded, riveted and bolted construction shall comply with SANS 1431: Weldable Structural Steels. Mild steel for load-bearing components shall not be inferior to Grade 300W.

b) Corrosion resistant steels used in construction shall comply with EN 10088 and that used for pressure linings shall comply with EN 10028-7.

c) The Contractor shall provide the Engineer with copies of mill rolling sheets for all sections incorporated in the Works, together with test certificates certifying that the steel has been tested and found to comply with the appropriate Standards. The Engineer reserves the right to test samples of steel independently and the results of these tests shall take precedence over the tests carried out by the rolling mill. Marking by the steel maker and the mills shall comply with BS 4360.

28.7.3 Stainless Steel

a) Unless otherwise specified, stainless steel shall have resistance to atmospheric corrosion not less than that provided by BS 970, Grade 304L and BS ISO 16143.

b) Particular attention shall be paid to the prevention of seizure by fretting where two (2) corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants.

c) Stainless steel shall be pickled and passivated after fabrication and welding. Re-passivation may be ordered, post-installation, at no additional cost should there be evidence of ferrous re-contamination. Refer also in this regard to Section 37 - Painting and Corrosion Protection.

28.7.4 Lamellar Tearing

The Contractor shall design, detail and fabricate all junctions in steelwork in such a way as to prevent failure by lamellar tearing.

28.7.5 Structural Steelwork Fabrication

a) Fabrication of structural steelwork shall be generally in accordance with BS 5400 unless otherwise specified.

b) The Contractor shall ensure that all surfaces requiring corrosion protection are either:

   i) Accessible for maintenance of the protection by reasonable methods when in position in the Works; or

   ii) Enclosed in hermetically sealed voids, where it is structurally safe to seal such voids. The voids shall be proved to be sealed by air pressure testing.

c) All permanently exposed edges and corners of members of fabricated steelwork shall be formed or dressed to a rounded profile with a minimum radius of approximately 2 mm to ensure an even coating of the protection to such parts of the fabrication.

d) All cutting, chamfering and other shaping of metals necessary for Site connections shall be done in the shop. Adequate provision for temporary bolted Site connections or clamps shall be provided to hold assemblies rigid and in proper alignment during Site welding. After welding, all temporary connections and clamps shall be removed and all bolt holes shall be plugged, welded over and ground down flush with the adjacent metal on both faces.

e) Bending and pressing of plates may be by either the hot or cold process. In no case shall the internal radius of bends in cold-bent plates be less than twice the thickness of the metal. The procedures used, including temperature control in the case of hot-forming. Where necessary, allowance shall be made in the design for possible modification of material properties.

f) Edges of all plates and members shall be square, clean, free from burrs and true to dimensions. If flame cutting is employed, edges shall be dressed smooth and true.

g) All bolts and nuts shall be in accordance with SANS 1700.

h) All bolt holes shall be drilled, not punched. Templates shall be used where applicable.

i) Large washers of at least twice the thickness of a standard washer shall be used on all fasteners going through slotted holes.

28.7.6 Surface Defects in Fabricated Steelwork

a) All fabricated steelwork shall be free of surface defects in the steel, burrs, sharp or rough edges, crevices, cracks or discontinuities in welded joints and depressions, hollows or moisture retaining features in locations where rain, spray or condensed moisture left in contact with the structure may promote corrosion of the steel. The dressing of the steel to remove burrs and rough edges from holes or cut lines shall be carried out as soon as possible after their presence has been detected consistent with the need to clean and give initial protection to exposed steel elsewhere on the plate, section or fabrication concerned.

b) Surface defects shall be ground out. The extent and depth of laminations shall be determined before any rectification is carried out. Provided the size and extent of any surface defect or lamination is not such as to warrant rejection of the steel plate or member on structural or other grounds, the area affected by the remedial work shall be cleaned and protected to the same standard as the rest of the plate or member.

c) Where necessary (e.g. to meet dimensional tolerances) the steel surface at such defective areas may be built up by welding including any preheating that might be required and ground flush with the surrounding steel surface before being cleaned and protected. This welding is to be stress-relieved by post-weld heat treatment.

28.8 WELDING

28.8.1 General

Welding of pipes and pipe specials shall be done in accordance with Section 32 – Pipes and Pipe Specials and Section 33 – Laying and Pressure Testing of Steel Pipes. All other welding of mechanical Plant shall be done to the requirements below.

28.8.2 Primary Requirements for Welding

(a) Welder's Qualification

The Contractor shall only use welders suitably qualified in terms of the relevant part of SANS Standards 10044, and shall submit to the Engineer copies of the qualifications of all welders to be employed in the fabrication of items prior to commencement of any such fabrication.

Welders will be required to be re-qualified for the welding procedures in respect of which they have approved qualifications should they not have been employed on work involving these procedures for a period of six (6) months or longer.

(b) Weld Procedure Specification

The Contractor shall also submit to the Engineer a copy of his Weld Procedure Specifications in terms of the relevant part of the aforementioned SANS Code. These documents shall contain full details of welding procedure, detail drawings of welds and weld preparations. The Contractor shall carry out such welding procedure tests as the Engineer may order to prove the sufficiency of his proposed procedures.

No welding shall commence until all welding procedures have been reviewed by the Engineer.

Shop and Field Fabrication Method Statements / QCP's shall be provided detailing welding distortion mitigation or elimination strategies before manufacture commences.

All welds shall be identified to enable each weld to be traced to the welder by whom it was made.

Pre-heating shall be carried out as recommended in BS EN 1011 PART 2 (2001) read in conjunction with PART 1 (1998) or other appropriate British Standard.

Full throat thickness shall be ensured at the ends of butt welds by the use of extension pieces or by other suitable means. If extension pieces are used they shall be clamped to the work and not welded. To ensure full penetration in butt welds, the use of backing material shall not be permitted.

(c) Welding Standards and Heat Treatment

All welding of the various types of steel used in fabrication shall be in accordance with the relevant South African or British Standards, or as specified below, and shall include for preheating of the components where required.

In particular the requirement for materials, details of butt and fillet welds, welding procedure details, inspection and testing and heat treatment as specified in BS EN 1011 PART 2 read in conjunction with PART 1 for the welding of mild steel and carbon manganese steels, respectively, shall apply. The welding of stainless steel shall be in accordance with the various most recent welding guidelines published by Columbus Stainless, SASSDA or equivalent publications, at the time of Tender.

Welding equipment, electrodes and rods shall conform to the requirements of the appropriate SANS and BS Standards such as SANS 954 for metal-arc welding equipment, SANS 455 for covered electrodes for manual arc welding of carbon and carbon manganese steels and BS EN ISO 3581 for chromium and chromium-nickel steel electrodes for manual metal-arc welding of stainless steel. The storage and handling of all consumables shall be in accordance with BS EN 1011 PART 2 read in conjunction with PART 1.

All components subjected to heat during fabrication shall be properly stress relieved in accordance with the requirements in the relevant SANS or BS Standards and in particular the most recent guidelines published by Columbus Stainless in the case of stainless steels.

All welds between plates 12 mm or greater in thickness whether carried out in the shop or at the Site shall be stress-relieved by post-weld heat treatment.

28.8.3 General Weld Quality

All welds shall be continuous and even, with no contact gaps or crevices left between members or unfilled re-entrant corners which would harbour moisture or dirt and prevent the satisfactory application and retention of the corrosion protective system.

Removal of slag from welds which will be subject to tensile stresses shall be carried out by grinding or blast cleaning.

The finish of the welded joint shall be free from irregularities, weld splatter, grooves and depressions. Undercutting at the welded joint shall not be permitted. Where welds are ground smooth, grinding shall where possible be in the direction of the principle stress. All fabrications which are subsequently to be machined in any way shall be stress relieved prior to machining.

28.8.4 Acceptance Tests for Welding

28.8.4.1 General Requirements for Quality Assurance

The soundness of welding shall be meticulously confirmed by the Contractor by means of examinations and non-destructive testing as described below.

All welds shall be visually examined and shall conform to the requirements stated in Section 8 of SANS 10044: Part 3. In addition to the visual examination the welds shall also be inspected and tested by other non-destructive methods referred to below with the extent of additional testing varying with the type of loading and exposure to which the weld will be subjected.

The Contractor shall keep a complete record of all examinations and testing of welds, copies of which shall be submitted to the Engineer. Any rectification of faulty welds as a consequence of the above examination procedures shall also be recorded and filed with the test records.

28.8.4.2 Fillet Welds

The Contractor shall provide a set of gauges to allow for fillet welds to be checked for throat thickness and profile by the Engineer.

All fillet welds shall be checked by means of magnetic particle or penetrant testing to prove that the weld metal, the heat affected zones and the surrounding parent metal are all free from cracks. Magnetic particle testing of welds shall be carried out in accordance with BS EN ISO 9934-1 while the method for penetrant testing shall conform to the requirements of BS EN ISO 3452-1.

28.8.4.3 Butt Welds

All butt welded joints shall be tested by means of radiographic examination in accordance with BS EN ISO 17636.

When examined radiographically, butt welds shall comply with the requirements for Grade B welds stated in Clause 8.2 of SANS 10044: Part 3.

28.8.5 Weld Defects and Repair

The Engineer shall be notified of all defects before any repair work is commenced and the repair technique shall be subject to the review of the Engineer. All repairs shall be subject to re-testing as specified above.

Where the re-testing of a repair reveals further unacceptable defects then the whole weld shall be cut out, re-welded and re-tested. No weld shall be repaired more than twice.

All repairs shall, if practicable, be carried out by the same process as was used for the original weld.

28.9 FASTENERS

a) Nuts and bolts for pressure parts shall be the best quality bright steel, machined on the shank and under the head and nut.

b) Bolts and studs shall be of such standard length that a minimum of two (2) to four (4) complete threads shall protrude beyond the nut when in the fully tightened condition. Mating surfaces shall be adequately protected against corrosion.

c) All bolting shall comply with the general requirements of BS 5400.

d) Mild steel bolts, rag bolts, nuts and washers shall conform to BS 4360 grade 43D or such higher grade as may be required for steel temperatures down to -30˚C as regards material. Nuts and bolts shall conform to BS 4190 as regards dimensions. Washers shall conform to BS 4320 as regards dimensions unless otherwise specified.

e) All high tensile bolts and studs used shall bear the letter HTS stamped or engraved on the end.

f) Washers shall be provided under all bolt heads and nuts.

g) The threads of bolts and studs shall be cleaned and coated with a Molybdenum Disulphide lubricant or Nickel Anti-seize compound before assembly.

h) Stainless steel bolts, nuts and washers shall be in accordance with SANS 1700 A70 grade 316L+. Threads shall be rolled and of a high quality surface finish.

i) Hot Dip Galvanised fasteners shall comply with the requirements of SANS 121.

j) High strength friction grip bolts, nuts, load indicator washers and washers shall comply with BS EN 14399 and BS 4604 and shall be hot dip galvanised. High strength friction grip bolts shall be tightened in accordance with the manufacturer's recommendations and the tension shall be re-checked not less than 3 hours after first tightening and then the bolts shall be re-tightened to the initial load.

k) Fitted bolts shall be a light driving fit in the reamed holes they occupy, have the threaded portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site. Unless otherwise specified the tolerance on the specified diameter of dowels shall be -0.05 mm to -0.20 mm for use in holes for fitted bolts.

l) Service bolts shall have the same nominal diameter as the specified permanent bolts. Where it is important that there shall be no movement prior to final connection, sufficient dowels, close tolerance bolts or high strength friction grip bolts shall be used to locate the work. All service bolts shall be replaced by the specified permanent bolts.

m) Washers, locking devices and anti-vibration arrangements shall be provided where necessary.

n) Where bolts pass through tapered structural members, matching taper washers shall be fitted where necessary and be orientated correctly to ensure that no bending stress is caused in the bolt.

o) Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt and nut does not exceed half of the yield stress of the bolt material under all conditions. The shear value of high strength friction grip bolts shall be reduced in proportion to the reduced tensile stress compared with the normal design stress.

p) No tapped holes in mild steel shall be allowed. Where tapped holes are unavoidable, this shall be done into stainless steel.

q) Where bolts and nuts are required to be removed and re-assembled on a regular basis, these shall be of stainless steel.

r) Metal coatings and other treatments applied to fasteners shall be carried out in a manner which will not cause hydrogen embrittlement of the parent material.

28.10 FLANGES AND GASKETS

28.10.1 General

a) Flanges shall be designed and manufactured to BS EN 1092 Part 1 for steel flanges and Part 2 for cast iron flanges, unless otherwise specified on the drawings. Flanges not covered by BS EN 1092 shall be manufactured according to NWS 1676 Revision 0 dated May 1981 (included as Annexure 28/4 to this section). Unless otherwise indicated on the drawings, flanges shall be of forged Grade 300WA steel or ASTM A105.

b) Sealing faces shall be machined flat to a tool-mark of 0.8 mm to 1.25 mm pitch spiral or concentric serrations and back of flanges to be either machined or spot-faced around holes with sufficient clearance to ensure proper seating of bolt heads and nuts. All bolt holes shall be drilled perpendicular to the flange face. Bolt holes shall be positioned off-centre and symmetrically off-set from the vertical centre lines of the flange and flanges shall be installed truly square to the axis of the pipe. The Contractor shall check the compatibility of drilling of all flanges to be connected together.

c) Flange thicknesses and bolt sizes shall conform to the appropriate table of BS EN 1092 or NWS 1676 Revision 0 dated May 1981 for flanges not covered by BS EN 1092 (Annexure 28/4).

d) The Contractor shall ensure that flanges supplied by him match the flanges to be connected to.

e) All flanges designed for pressure ratings up to and including 1600 kPa, shall be flat faced with full face gaskets. Flanges designed for pressure rating exceeding 1600 kPa shall be raised face flanges supplied with ring gaskets. Flanges with pressure ratings of 6400 kPa and higher and flange sizes of 2500 mm diameter and larger, irrespective of pressure rating, shall incorporate an “O” ring groove. Details of the “O” ring groove shall be furnished by the Contractor for review by the Engineer.

f) All gaskets supplied under this Contract shall be of tanged graphite full face for flat joint faces and aramid and glass fibre with nitrile rubber binder to BS 7531 ring face for raised faces. Gaskets shall be suitable for the specified pressures with a minimum thickness of 3 mm and purpose made to the dimensions of the matching flanges. Joints in gaskets shall be kept to the minimum. Where not avoidable, joints shall be a tight fitting dovetail design.

g) All mill scale on flanges shall be removed by abrasive blasting before flanges are fitted and welded to pipes and fittings.

h) All flanges shall be supplied complete with bolts, nuts, washers and gaskets. Fasteners shall comply with SANS 1700 Grade 8.8 minimum and shall be hot dip galvanized to SANS 121 standards or stainless steel grade 316L where specified. Washers shall be installed under the nut as well as the bolt head to protect the paintwork.

i) Rubber joint rings shall comply with SANS 4633.

j) Puddle flanges shall not be drilled.

28.10.2 Restraining Flanges

a) Where longitudinal movement is possible, flexible couplings and flange adaptors shall be restrained by means of a restraining flange and associated restraining bolts. Unless the diameter, number and length of the long restraining bolts as well as any possible pipe wall thickening are shown on the drawings, these parameters shall be specified by the Contractor in consultation with the manufacturer. The effect of cyclic loading and fatigue must also be taken into consideration.

b) Restraining flanges do not require all the bolt holes specified in the applicable flange drilling table. Only those required for the long restraining bolts need to be provided. These holes must comply with the applicable flange drilling table and be spaced equally on the restraining flange and symmetrically around the flange centre lines.

c) Restraining bolts to be positioned to avoid interference with any stubs specified for an item.

28.10.3 Blank (Blind) Flanges

Blank flanges for pipes equal to or greater than 400 mm diameter (including the ones with pipe stubs welded on it) shall be provided with two (2) suitable lifting handles with coating similar than the blind flange.

28.10.4 Insulating Flanges

Insulating flanges shall comply with Section 34.

28.11 MISCELLANEOUS MATERIALS

28.11.1 Cast Iron

a) Cast iron shall be of the nodular or spheroidal graphite type to SANS 936/937 grade SG42 or to such other grade as specified by the designer.

b) Cast iron shall not be used for components subject to impact stresses.

c) The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions and other injurious defects.

d) The Contractor shall perform all tests listed in SANS 936/937 together with the following additional tests on specimens from each batch:

   i) Each tensile test shall include determination of the 0.2% proof stress value; and

   ii) Three (3) impact tests shall be performed on samples from each batch of castings at normal ambient temperatures and 3 further tests at an ambient temperature of -30˚C. The average impact value of each set of tests shall be such as will be suitable for the operational temperatures of each item made from the batch.

e) The Contractor shall non-destructively test all castings using radiographic, magnetic particle, penetrant and ultrasonic flaw detection methods as appropriate, similar to those specified in BS 4080.

f) Minor defects shall be chipped or grooved out by a carbon arc air process to sound clear metal and repaired by welding. Castings with defects which do not otherwise affect the performance of the castings but which necessitate the removal of metal resulting in a reduction in the stress-bearing cross-section of a component by more than 20% may be rejected by the Engineer.

g) Welding shall only be carried out by qualified welders and all such repairs shall be subject to stress relief.

h) Radiographic and/or ultrasonic testing shall be carried out on the areas around all defects in any casting after removal of metal to ensure that each defect has been properly removed.

i) Certified copies of the results of all tests shall be furnished to the Engineer.

28.11.2 Steel Castings

a) The steel used for castings shall comply with Clause 28.8 and with BS EN 10293. Castings shall be heat treated.

b) The Contractor shall perform all the tests listed in BS EN 10293, together with the following additional tests on specimens from each batch:

   i) Brinell hardness tests; and

   ii) The impact tests specified in Clause 28.11.1.

28.11.3 Forgings

a) Steel for forging shall be of the quality appropriate to each particular item and shall comply with BS 970, as appropriate.

b) All forging shall be heat-treated for the relief of residual stresses before the start of machining.

c) The forging shall be inspected by the Contractor using radiographic methods similar to those set out in BS 4080 for steel castings and also using the ultrasonic, magnetic particle and penetrant flaw detection testing techniques set out in BS EN 10228.

28.11.4 Fabrics, Wood, etc.

a) Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with suitable fungicide. Sleeving and fabrics treated with linseed oil varnish shall not be used.

b) The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

c) The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other suitable hardwood which is resistant to fungal decay and free from shakes and warp, sap and wane, knots, faults and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, bacteria or chemical attack, unless it is naturally resistant to those causes of deterioration. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture. Synthetic resin cement only shall be used for joining wood. Casein cement shall not be used.

28.11.5 Bronze

Where bronze is specified or used it shall be zinc free.

28.11.6 Bright Parts

Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

28.11.7 Adhesives

All adhesives shall be specially selected to ensure use of types which are impervious to moisture and are resistant to mould growth and other forms of attack or deterioration.

28.11.8 Asbestos

Asbestos and materials containing asbestos shall not be used.

28.12 CORROSION PROTECTION

All Plant shall be designed to suppress corrosion in an exposed environment. Preparation works and corrosion protection of all mechanical Plant shall be in accordance with Section 37 – Painting and Corrosion Protection. Special attention shall be given to the compatibility of materials.

28.13 BEARINGS

28.13.1 General

a) The material from which all parts of bearings, including housing, spigots and bedplates are to be made shall be in accordance with the bearing manufacturer's recommendations.

b) Each bearing shall be designed to transmit safely axial and radial loads likely to be applied to it under all conditions both during operation and at rest. The L10 design life of rolling bearings shall not be less than 10 000 hours based on the most severe dynamic and static load condition, whichever is the more severe, for the particular bearing. Bearings shall be designed and manufactured from materials suitable for carrying static loads for not less than 50 years with very infrequent operation.

c) Each bearing shall be installed to allow removal for maintenance or replacement without damage to either the bearing or the adjacent parts of the installation.

d) All bearings including self-lubricating bearings shall be sealed against the ingress of deleterious contaminants and shall be provided where necessary with means of lubrication to the centre of the bearing so that any foreign matter is expelled through the end seals during the lubrication process.

e) Each bearing shall be lubricated, the lubrication stations being situated in weather-proof and accessible positions.

f) Except in the case of roller bearings which shall be installed generally in accordance with the bearing manufacturer's recommendations, the backing plates, outer sleeves (or housing) and the inner sleeves (where provided) of bearings shall be fixed to their respective adjacent structural members by such positive mechanical means as keying or similar, so that the movement in the bearing shall take place only between the bearing surfaces.

g) Where the housing of any bearing is welded to steelwork the housing shall be machined to the required tolerances to receive the bearing after completion of fabrication and heat treatment.

h) Where bearing housings are bolted into steelwork the design of the connection shall be such that distortion of the bearing housing does not occur when it is tightened down.

i) All bearings except self-lubricating bearings, which when in use will be subject to small displacements or small angular rotations only, shall be run-in before incorporation in the Plant. Each self-lubricating bearing shall either be run-in or prepared and pre-coated so that the lubricant is evenly distributed over the whole bearing surface. All other bearings shall be run-in before the start of or during the Site tests.

28.13.2 Self-Lubricating Bearings

a) Self-lubricating bearings shall be of the Lubrite type as manufactured by Merriman Inc., of Hingham, Massachusetts, USA or equivalent. These bearings may be of the plain type or, where the alignment of the bearing is subject to change under varying loads due to structural deformations of the gates or other parts of the Plant shall be of the self-aligning type.

b) Self-aligning bearings shall have an inner spherical section manufactured from aluminium nickel bronze and a split outer housing of stainless steel.

c) The spherical surface shall be for taking up misalignment and the bearing shall run on the cylindrical inner surface; the split housing shall be locked against rotation.

d) The spherical and cylindrical surfaces shall be inlaid with and covered with solid lubricant.

e) The lubricant shall have non-deteriorating characteristics and shall be capable of withstanding the effects of long-term exposure to atmospheric pollution and submerged environments at the Site.

f) The lubricant shall be epoxy based and shall be free of graphite and all other constituents which may lead to fretting corrosion, electrolytic corrosion or chemical action of any part of the bearing.

g) The lubricant shall be contained in recesses machined in the inner diameter and spherical surface of the bronze ball section. The recesses shall cover an area of not less than 30% of the projected area of the bearing surfaces. The lubricant shall be compressed into the recessing by a pressure of at least twice the designed unit loading.

h) The lubricant shall be compatible with greases used during assembly and subsequently injected during operation for the exclusion of moisture and dirt.

i) The surfaces on which bearings rotate and or slide shall have a hardness exceeding that of the bearing material by 100 points on the Brinell hardness scale or as otherwise required by the bearing manufacturer.

28.13.3 Other Bearings

a) Where large pedestal type roller bearings are used to support slow moving parts, the bearings shall be, where practicable, heavy duty self-aligning split roller bearings. Bearings shall have cast steel or fabricated steel housings or plumber blocks. Cast iron housings and plumber blocks shall not be used.

b) All high-speed shafts shall be provided with ball or roller bearings and they shall be mounted in dustproof housings and lubricated by grease gun.

c) Other bearings shall be of the adjustable cap type where practicable and shall be fitted with grease lubricators.

d) All cylindrical journal bearings shall be bushed with bronze or white metal and shall be accurately bedded and grooved.

e) The underside of the base of each bearing shall be machined and shall bear against a machined surface.

28.13.4 Lubrication

a) Lubrication shall be provided to all moving parts using either oil or grease. A separate oil cup or grease nipple shall be used to lubricate each point. Grease lubrication shall be provided with stainless steel button head type (1/8" BSP) and shall, together with oil filler caps or plugs, be painted red for easy identification. Lubricating nipples and adapters shall conform to the requirements of BS 1486.

b) Where necessary for accessibility, the nipples shall be placed at the end of a short extension piping. Where possible such nipples shall be grouped together and each group shall be mounted on a plate situated at a convenient point for the use of a grease gun which shall be provided under the Contract.

c) A grease gun with connections to suit the nipples shall be provided with each unit of Plant.

d) Before putting the Plant to work, all grease points and gearboxes, etc., shall be charged as required with the appropriate lubricant.

e) Oils and greases must be suitable for the Site conditions.

28.14 OIL WATER SEPARATOR (OWS) FOR PUMPING STATION

a) An Oil Water Separator (OWS) is required to extract the oil from the water in the drainage sump of any proposed pumping station. The OWS shall be of the centrifugal type, i.e.; hydro-cyclone fitted with a suction hose and surface suction device. Fixed weir, rope, belt, disc or similar skimmers will not be considered.

b) The effluent shall be drawn through a floating self-adjusting oil skimmer in the sump pit and then drawn through a strainer to the OWS. The strainer shall remove small amounts of debris and particles. A pump shall provide the pressure to drive the fluid through the OWS with the treated water discharged under pressure back into the drainage sump. The separated oil, which may include some water, shall be sent to an oil collection tank. Any excess water in the oil collection tank shall automatically be drained from the tank back into the sump pit. When the oil level in the oil collection tank reaches maximum level a micro switch shall stop the separator, turn on an indicator light on the separator and relay a signal to that effect to the SCADA. The main drainage pumps shall switch off when the water level in the sump is sufficiently low for the surface suction device to operate effectively.

c) The pump shall be protected by use of low and high-pressure switches. Low-pressure protection shall indicate low or no pump flow conditions and prevent dry running. In addition to the switches overpressure protection shall also be achieved with a mechanical pressure relief valve. The system shall be configured to operate via an isolation switch on the local control box. The IP rating of the local control box shall be IP56. The OWS should run continuously or in response to level or process controls. A local isolation switch shall be

required to turn the unit off for maintenance and/or repair purposes. The OWS shall be configured to operate automatically and with little operator attention.

d) The OWS shall be designed to operate for an average of 4 hours per day with a primary design life of greater than 20 years.

e) The Contractor shall furnish all components and ancillary Plant necessary to meet the requirements and to make a complete, functional, safe and reliable unit.

f) The Contractor's scope shall include, but not limited to, the following:

- Oil Separator;
- Automated backflush including actuated valves and control logic;
- Suction and feed pump;
- Floating skimmer assembly with hydrocarbon resistant hose;
- Feed strainer;
- OWS controls; and
- Oil collection and decant tank;

28.15 NAMEPLATES, RATING PLATES AND LABELS

a) Where appropriate, each item of Plant shall have permanently attached to it in a conspicuous position a nameplate upon which shall be engraved or stamped the manufacturer's name, type and serial number of Plant, Part number, Contract number, order number, date of manufacture, mass, material and all necessary information relating to the supply and replacement of parts and details of the loading and duty at which the item of Plant has been designed to operate. A nameplate denoting the Plant or function identification number shall also be attached. Such nameplates shall be of stainless steel.

b) Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control Plant mounted externally and internally.

c) Externally fitted panel labels shall be of non-plastic, durable, weather resistant material with letters and numbers engraved and filled with black.

d) Internally fitted panel labels shall be finished white and engraved letters and numbers filled with black, laminated material such as "Trifoliate" or rear engraved and filled plastic may be used. Embossed materials and techniques will not be accepted.

e) Labels shall also be provided in conformity with the above requirements or by other suitable means wherever necessary to designate panels or panel sections, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this Section.

f) Danger labels e.g. "DANGER – 400 V AC" shall be coloured red with white lettering.

g) Caution labels e.g. "CAUTION-ISOLATE BEFORE REMOVING COVER" shall be white with red lettering.

h) Where withdrawable Plant is provided both fixed and moving portions shall be suitably identified.

i) Labels shall be of uniform design and the display of manufacturers' standard nameplates on panel external surfaces shall be subject to the acceptance of the Engineer.

j) Details of proposed inscriptions shall be submitted to the Engineer for review before any labels are manufactured.

k) All nameplates and labels shall be fixed using non-corrosive fasteners. Adhesive only shall not be acceptable.

28.16 LIFTING DEVICES

a) The Contractor shall prepare drawings and full instructions as to the means to be employed for inserting and withdrawing the gates and other Plant. These drawings shall include a table listing the requirements for all lifting operations, means of identification of grappling beams, slings, etc.

b) All special apparatus, including one (1) set of such grappling beams, slings, lifting beams, spreader beams and attachments as may be necessary for lifting any part of the Plant and Plant items shall be provided by the Contractor. Attachments shall be permanently tagged or marked for identification purposes. Any special lifting apparatus employed in the erection of the Plant shall be handed over to the Employer in "as new" condition on completion of the work.

c) A load plate showing the safe working load shall be fixed to each lifting device by means of stainless steel fasteners and in a position easily legible from the operating level.

28.17 ERECTION

28.17.1 Foundation Bolts and Fittings

a) The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packing required to attach the items of Plant to the foundations, and all bed-plates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

b) All bed plates and machinery shall be connected to concrete plinths by means of grout arranged so as to transmit all vertical and horizontal loads into the foundations by means of direct compressive stress.

c) The bed plates and machinery shall be provided with means of adjustment for line and level to maintain the items of Plant in correct alignment during grouting. Packers used for adjustment shall be of non-corrosive material.

d) Holding down bolts which are to be tightened after grouting shall be provided with bond breakers where they pass through the grout.

e) Holding down bolts, nuts and washers shall be of stainless steel and provided with isolating washers and sleeves where appropriate to prevent galvanic corrosion.

28.17.2 Accuracy of Work: Gates, Guides and Mechanical Plant

The required accuracy and tolerances for the erection of gates, guides and mechanical Plant shall be determined by the Contractor. These shall not be less than the requirements stated in the Modular Standards for that particular Plant and shall be subject to review by the Engineer.

28.17.3 Grouting

a) Concrete for embedding second stage built-in parts shall be supplied, mixed and placed as specified by the designer.

b) Grout for the connection between bed plates and machinery and concrete shall be non-shrink epoxy grout and shall be mixed and placed in accordance with the design requirements.

c) Non-shrink grout shall:

   i) Have a compressive strength not less than four (4) times the maximum stress to be transmitted;

   ii) Be subject only to compressive stress;

   iii) Be such that air voids are eliminated between bed plates and machinery and concrete;

   iv) Be completely resistant to lubricants, hydraulic fluids and diesel fuel;

   v) Have bond strength to concrete exceeding the tensile strength of the concrete; and

   vi) Have bond strength to steel not less than (v) above.

28.17.4 Drilling the Structure for Fixings

a) The drilling of holes for fixing devices shall be carried out by specialist workmen. Holes shall be made with a rotary drill or a rotary/percussion type drill such that no damage or spalling is caused to the concrete and/or brickwork being drilled. Explosion or impact devices such as single shot cartridge tools shall not be used.

b) The performance of the structural steel, reinforcement or timber work shall not be affected by drilling.

28.18 INSPECTION, TESTING AND QUALITY CONTROL

28.18.1 Inspection and Testing

28.19.1.1 Factory Acceptance Tests (FAT)

All Plant shall be subject to a Factory Acceptance Test (FAT), to be witnessed by the Engineer at the manufacturer's premises before despatch. No material shall be delivered to the Site without the FAT, unless it was waived by the Engineer.

28.18.1.2 Type Tests

Where the Contractor offers Plant selected from the standard range of products from a specialist manufacturer, type tests in accordance with a recognised international standard are required on one (1) unit of each type to prove satisfactory design and quality of manufacture of that Plant.

The Engineer may waive the requirement for type tests if he is satisfied that tests have previously been performed on identical Plant. The Contractor shall submit the data and results with his Quality Plan

28.18.1.3 Routine Tests

a) The Contractor shall carry out routine tests in accordance with the requirements of the Quality Control Plan on all items of Plant during manufacture to demonstrate satisfactory materials, workmanship, assembly and functionality of Plant.

b) Detailed proposals for routine tests shall be included in the Contractor's Quality Plan, covering where applicable:

   i) Material tests;

   ii) Non-destructive tests;

   iii) Dimension and finish checks;

   iv) Pressure tests;

   v) Assembly checks;

   vi) Paintwork tests;

   vii) Electrical tests;

   viii) Functional tests;

   ix) Load tests; and

   x) Performance tests.

c) After assembly, each unit shall be carefully checked to ensure that it is in accordance with the specified dimensions.

d) The Contractor shall repeat such routine tests as are necessary to confirm that the Plant has not been damaged in transit, has been satisfactorily erected, and is ready for pre-commissioning.

28.18.1.4 Destructive Testing

The Engineer may carry out destructive tests to ascertain compliance with the specifications.
Non-destructive Testing During Manufacture

a) All welds on Plant shall be physically checked for compliance with the specification and for throat thickness in the case of fillet welds. If judged to be satisfactory from a physical external examination they shall then be non-destructively tested by means of radiographic, ultrasonic, magnetic particle or dye penetrant methods, as appropriate. If post weld heat treatment is required non-destructive tests shall be done after completion of heat treatment. Prior acceptance for the use of ultrasonic (or other) methods in place of radiographic methods shall be obtained from the Engineer.

b) Radiographic examination shall be in accordance with BS EN ISO 17636. Normally X-ray techniques shall be used with ultra-fine-grain-high-contrast direct-type film.

c) The standards of acceptance shall be as defined in PD 5500 Table 5.7 - Acceptance Levels.

d) The Contractor shall supply all apparatus, materials and labour required for his own non-destructive examinations and for non-destructive examinations ordered by the Engineer.

28.18.1.5 Non-destructive Testing on Site

For Site welding, ultrasonic examination of in-situ welds shall be done where radiographic examination is not practicable. Ultrasonic examination shall be in accordance with BS EN ISO 17640. Adjacent parent metal shall be ultrasonically examined to locate any imperfections which might prevent effective examination of the weld.

28.18.2 Quality Control Records

a) Accurate and detailed quality control records shall be kept by the Contractor for all stages of the work.

b) Examples of QCP's for valves are attached at the end of this Section:

- Quality Control Plan for Corrosion Protection (Annexure 28/1);
- Coating Application Records (Annexure 28/2); and
- Surface Profile and Dry Film Thickness readings (Annexure 28/3).

c) All the quality control records shall be available for review by the Engineer.

d) Incomplete, inaccurate or inadequate records shall be regarded as non-compliance with the specification.

e) Quality control, material and coating records for all stages of the work, i.e. batch numbers of materials used, environmental conditions and all test data shall be recorded on the record sheets attached to the Quality Control Plans for manufacture and corrosion protection.

f) Certificates for all materials used shall also be required.

28.19 OPERATION AND MAINTENANCE MANUALS

Submission of O&M Manuals shall be as required under Section 48 – Tests on Completion.

28.20 OCCUPATIONAL HEALTH AND SAFETY

This clause shall be read in conjunction with Section 2 – Occupational Health and Safety.

a) All Plant, including the design, and equipment shall comply with the OHS Act (No 85 of 1993) and its Regulations.

b) All shafts, couplings, collars, projecting key heads, gear wheels, chain drives and other moving machinery shall be guarded to give complete protection to all persons. All set screws on revolving shafts shall be countersunk or suitably protected. The guards shall be of suitable design and shall be fitted where necessary with inspection doors. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and Plant they protect. The guards shall comply with the requirements of BS 1649 or equivalent standard.

c) Fencing or other safeguards for electrical Plant shall be completed before connection is made to the electricity supply.

d) If work in the vicinity of electrical Plant has to be carried out after connection has been made to the electricity supply, the Contractor shall comply with any "Permit to Work" system.

e) All Plant shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.

f) No protruding items of a permanent nature shall be allowed on the deck or any other moving part within the working area.

ANNEXURE 28/1
QCP FOR CORROSION PROTECTION OF VALVES

QUALITY CONTROL PLAN FOR CORROSION PROTECTION OF VALVES

PROJECT:			QCP NO.
EQUIPMENT:		SECTION:	REVISION:
DRAWING NO.:	QTY:	FACTORY ID NO.:	COMPILED BY: DATE:
CLIENT:		CONTACT NO.:	ORDER NO.:
CONTRACTOR:		CONTACT PERSON:	
APPLICATOR:		CONTACT PERSON:	

APPROVALS

CONTRACTOR	ENGINEER	INSPECTOR
NAME: SIGNATURE: DATE:	NAME: SIGNATURE: DATE:	NAME: SIGNATURE: DATE:

LEGEND

H - HOLD POINT	W - WITNESS POINT	S – SURVEILLANCE	R – REVIEW

INSPECTION CODE

1 – APPROVAL	3 - TESTING	5 - REPORT REQUIRED	
2 – MATERIAL CERTIFICATE	4 - VISUAL	6 - RECORD REVIEW	

QUALITY CONTROL

	OPERATION	INSP. CODE	INSPECTION INTERVENTIONS			ACCEPTANCE CRITERIA	
			CONTRACTOR	ENGINEER	INSPECTOR		
1.	**DOCUMENTATION APPROVAL**						
1.1	Quality Control Plan	1					
1.2	Corrosion Protection Programme	1					
1.3	Coating Material	1				Data sheets	
1.4	Pickling and Passivation Material	1				Data sheets	
1.5	Rough Blast Material	1				Data sheets	
1.6	Final Blast Material	1				Data sheets	
2.	**PRE-PREPARATION**						
2.1	Dress Protrusions and Pits	4				Smooth surface	
2.2	Radius Sharp Edges	4				2 mm minimum radius	
2.3	Repair Blowholes in Castings	4				To be approved by Engineer	
2.4	Fettle Welds	4				Smooth contour	
2.5	Remove Weld Spatter, Burrs, Laminations, Scabs and Scale	4					
3.	**DEGREASING**						
3.1	Remove Oil/Grease Contaminations	3				Water break-free	
4.	**ROUGH BLAST CLEANING**						
4.1	Blasting Material						
4.2	Cleanliness						
5.	**MEASUREMENT OF SOLUBLE SALTS**					Wet surface	Dry surface
5.1	Max. at any point					100 mg/m²	500 mg/m²
5.2	Average over 250 cm²					<100 mg/m²	100 mg/m²
5.3	Wet cleaning/Re-blasting					Clean soft water	
6.	**FINAL BLAST CLEANING**						
6.1	Blasting Material	5				Data Sheet	
6.2	Cleanliness: Lining	4				Sa 3	
6.3	Cleanliness: Coating	4				Sa 2½	
6.4	Surface Profile	3				50-100 µm	
6.5	Residual Dust and Debris	3				0,3%	
7.	**AMBIENT CONDITIONS**						
7.1	Records	6					
8.	**APPLICATION OF FIRST COAT**						
8.1	Dry Film Thickness (DFT) - Lining	3				µm	
8.1	Dry Film Thickness (DFT) - Coating	3				µm	

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QUALITY CONTROL PLAN FOR CORROSION PROTECTION OF VALVES

PROJECT:			QCP NO.
EQUIPMENT:		SECTION:	REVISION:
DRAWING NO.:	QTY:	FACTORY ID NO.:	COMPILED BY: DATE:
CLIENT:		CONTACT NO.:	ORDER NO.:
CONTRACTOR:		CONTACT PERSON:	
APPLICATOR:		CONTACT PERSON:	

APPROVALS

CONTRACTOR	ENGINEER	INSPECTOR
NAME: SIGNATURE: DATE:	NAME: SIGNATURE: DATE:	NAME: SIGNATURE: DATE:

LEGEND

H - HOLD POINT	W - WITNESS POINT	S – SURVEILLANCE	R – REVIEW

INSPECTION CODE

1 – APPROVAL	3 - TESTING	5 - REPORT REQUIRED	
2 – MATERIAL CERTIFICATE	4 - VISUAL	6 - RECORD REVIEW	

QUALITY CONTROL

	OPERATION	INSP. CODE	INSPECTION INTERVENTIONS			ACCEPTANCE CRITERIA
			CONTRACTOR	ENGINEER	INSPECTOR	
9.	**APPLICATION OF SECOND COAT**					
9.1	Dry Film Thickness (DFT) - Lining	3				µm
9.1	Dry Film Thickness (DFT) - Coating	3				µm
10.	**APPLICATION OF FINAL COAT**					
10.1	Dry Film Thickness (DFT) - Coating	3				Brilliant Green SANS 1091 Code – H10 (25µm minimum)
11.	**COMPLETED SYSTEM**					
11.1	Visual appearance	4				
11.2	Dry Film Thickness (DFT) - Lining	3				400 µm minimum
10.3	Dry Film Thickness (DFT) - Coating	3				300 µm minimum
10.4	Dry Film Thickness (DFT) - Flange/ Mating Surfaces	3				60 – 90 µm minimum
10.5	Electrical Insulation Defect (EID)	3				Wet surface
10.6	Adhesion Test	3				Where required
12.	**STAINLESS STEEL UN-COATED COMPONENTS**					
11.1	Degreasing	5				
11.2	Pickling	5				
11.3	Passivation	5				

Page 2 of 2

ANNEXURE 28/2
SURFACE PROFILE AND DRY FILM THICKNESS READINGS

SURFACE PROFILE AND DRY FILM THICKNESS READINGS

PROJECT:			
EQUIPMENT:		SECTION:	
DRAWING NO.:	QTY:	FACTORY ID NO.:	
CLIENT:		CONTRACT NO.:	ORDER NO.:
CONTRACTOR:		CONTACT PERSON:	
APPLICATOR:		CONTACT PERSON:	

SURFACE PROFILE

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DFT FIRST COAT

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DFT SECOND COAT

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DFT THIRD COAT

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DFT FINAL COAT

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

FLANGE FACES

DATE:

FLANGE SIZE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE

COMMENTS:

ANNEXURE 28/3
COATING APPLICATION RECORD

COATING APPLICATION RECORD

1. Pre-preparation												
Dress protrusions & pits:												
Radius sharp edges:												
Repair blowholes in castings:												
Fettle welds:												
Remove weld spatter, burrs, laminations, scale & scabs:												
Primary cleaning:												
2. Degreasing												
Material reference				Batch number:								
"Water break free" test												
3. Rough blast cleaning												
Date of rough blast cleaning				Blasting material:								
4. Measurement of soluble salts												
Maximum at any point mg/m²				Average over 250 cm² mg/m²								
Maximum at any point – final reading mg/m²				Average over 250 cm² - final reading mg/m²								
Wet cleaning/Re-blasting				Blasting material:								
5. Final blast cleaning												
Blasting material:				Cleanliness - wet surface: Sa								
Material certificate No.:				Cleanliness - dry surface: Sa								
Material pH	Hardness Moh's scale			Residual dust & debris: %								
Surface profile:	Maximum: µm			Minimum µm			Average µm					
Date of final blast cleaning:				Time completed:								
6. Ambient conditions	**First coat**			**Second coat**			**Third coat**			**Final coat**		
Time	08:00	12:00	16:00	08:00	12:00	16:00	08:00	12:00	16:00	08:00	12:00	16:00
Rain: Yes/No												
Ambient temperature °C												
Substrate temperature °C												
Relative Humidity %												
Dew point °C												
7. Application of coats	**First coat**			**Second coat**			**Third coat**			**Final coat**		
Base : Material reference												
: Batch number												
Activator: Material reference												
: Batch number												
Thinner/solvent : Type												
: Batch number												
Application equipment:												
Colour:												
Surface preparation:												
Areas stripe coated:												
Date of application:												
Time application started:												
Time application completed:												
Wet film thickness:												
Wet surface DFT: Min / Ave	µm	µm		µm	µm		µm	µm		µm	µm	
No-off readings												
Dry surface DFT: Min / Ave	µm	µm		µm	µm		µm	µm		µm	µm	
No-off readings												
Flange/mating surface DFT:Min/Max	µm	µm		µm	µm		µm	µm		µm	µm	
No-off readings												
8. Completed system												
Visual appearance:												
Electrical Insulation Defect at V												
Adhesion test:												
Cure test:												
9. Stainless steel – uncoated components												
Degreasing												
Date of degreasing	Material reference:			Batch No.								
10. Pickling and passivation												
Date of pickling	Material reference:			Batch No.								
Date of passivation:	Material reference:			Batch No.								

ANNEXURE 28/4
EXTENDED FLANGE DIMENSIONS SPECIFICATION

(NWS 1676 based on BS 4504/BS EN 1092)

-

WDP/MvdM(1)S170

MAY 1981

NWS 1676 REVISION 0
DISTRIBUTION CODE 2.0/6.1

ELECTRICITY SUPPLY COMMISSION

NEW WORKS DEPARTMENT STANDARD

SPECIFICATION

FOR

DIMENSIONS AND DRILLING

OF STEEL PLATE FLANGES

FOR WELDING

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170002

NWS 1676 REVISION 0

1. SCOPE

This specification defines Escom's dimensional requirements for steel plate flanges for welding, when such flanges fall outside the range of BS 4504 : Part 1 : 1969. The dimensions specified are fully compatible with other types of flanges manufactured to BS 4504 : Part 1 : 1969.

2. GENERAL

2.1 Reference Documents

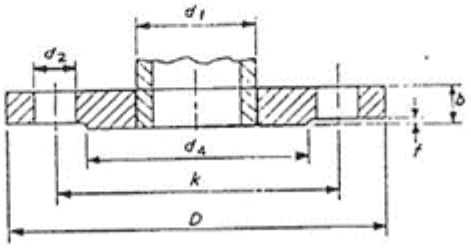
2.1.1 NWS 1459 : Specification for the design and manufacture of carbon steel pipe and specials.

2.1.2 BS 4504 : Flanges and bolting for pipes, valves and fittings. Metric series (Part 1).

170002

TABLE 1

STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 6/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE 0,6 MPa

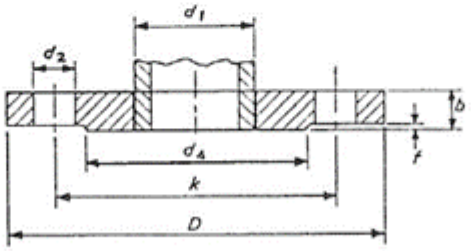


NOM. SIZE	PIPE OD	FLANGE RAISED FACE				BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	345	22	282	3	M16	8	18	305
550	558,8	705	30	620	4	M24	20	26	655
650	660,4	810	34	725	5	M24	20	26	760
750	762,0	920	36	825	5	M27	24	30	865
1100	1118,0	1305	52	1195	5	M30	28	33	1240
1300	1320,0	1520	60	1400	5	M33	32	36	1450
1500	1520,0	1730	70	1610	5	M33	36	36	1660
2200	2230,0	2475	96	2335	6	M39	52	42	2390
2400	2430,0	2685	106	2545	6	M39	56	42	2600
2600	2640,0	2905	112	2750	6	M45	60	48	2810
2800	2840,0	3115	122	2960	6	M45	64	48	3020
3000	3040,0	3315	130	3160	6	M45	68	48	3220
3200	3240,0	3525	138	3370	6	M45	72	48	3430
3400	3450,0	3735	146	3580	6	M45	76	48	3640
3600	3650,0	3970	154	3790	6	M52	80	56	3860

NWS 1676 REVISION 0

TABLE 2

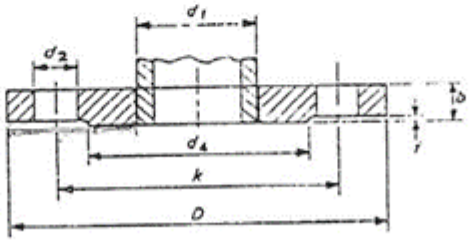
STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 10/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE = 1,0 MPa



NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	370	24	295	3	M20	8	22	325
550	558,8	730	40	635	4	M27	20	30	675
650	660,4	835	44	740	5	M27	24	30	780
750	762,0	965	50	855	5	M30	24	33	900
1100	1118,0	1340	68	1215	5	M33	32	36	1270
1300	1320,0	1575	78	1430	5	M39	32	42	1490
1400	1420,0	1675	84	1535	5	M39	36	42	1590
1500	1520,0	1785	90	1640	5	M39	36	42	1700
1600	1620,0	1915	96	1760	5	M45	40	48	1820
1800	1820,0	2115	106	1960	5	M45	44	48	2020
2000	2020,0	2325	118	2170	5	M45	48	48	2230
2200	2230,0	2550	126	2370	6	M52	52	56	2440
2400	2430,0	2760	138	2570	6	M52	56	56	2650
2600	2640,0	2960	148	2780	6	M52	60	56	2850
2800	2840,0	3180	162	3000	6	M52	64	56	3070
3000	3040,0	3405	174	3210	6	M56	68	62	3290

TABLE 3

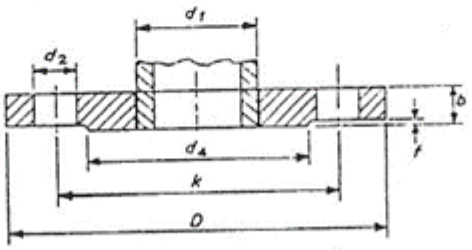
STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 16/3 IF BS4504:PART 1:1969
NOMINAL PRESSURE 1,6 MPa



NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	370	24	295	3	M20	12	22	325
550	558,8	775	48	635	4	M30	20	33	710
650	660,4	860	56	740	5	M33	24	36	790
750	762,0	970	60	855	5	M33	24	36	900
1100	1118,0	1355	84	1215	5	M39	32	42	1270
1300	1320,0	1585	98	1430	5	M45	32	48	1490
1400	1420,0	1685	104	1530	5	M45	36	48	1590
1500	1520,0	1820	110	1640	5	M52	36	56	1710
1600	1620,0	1930	118	1750	5	M52	40	56	1820
1800	1820,0	2130	132	1950	5	M52	44	56	2020
2000	2020,0	2345	146	2150	5	M56	48	62	2230
2200	2230,0	2555	158	2370	6	M56	52	62	2440
2400	2430,0	2765	174	2570	6	M56	56	62	2650

TABLE 4

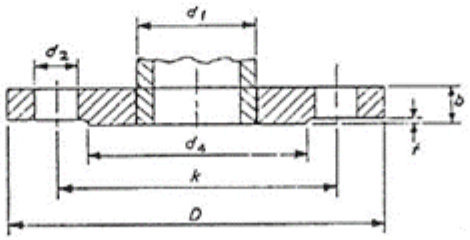
STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE WITH, 25/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE 2,5 MPa



NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
150	168,3	300	24	218	3	M24	8	26	250
225	246,1	395	30	305	3	M27	12	30	340
550	558,8	785	60	680	4	M36	20	39	710
650	660,4	895	70	770	5	M36	24	39	820
700	711,2	960	74	820	5	M39	24	42	875
750	762,0	1020	78	880	5	M39	24	42	935
800	812,8	1085	82	930	5	M45	24	48	990
900	914,4	1185	90	1030	5	M45	28	48	1090
1000	1016,0	1320	98	1140	5	M52	28	56	1210
1100	1118,0	1420	106	1240	5	M52	32	56	1310
1200	1220,0	1530	116	1350	5	M52	32	56	1420
1300	1320,0	1645	124	1450	5	M56	32	62	1530
1400	1420,0	1755	134	1560	5	M56	36	62	1640
1500	1520,0	1865	144	1670	5	M56	36	62	1750
1600	1620,0	1975	154	1780	5	M56	40	62	1860
1800	1820,0	2195	170	1985	5	M64	44	70	2070

TABLE 5

STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 40/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE 4,0 MPa



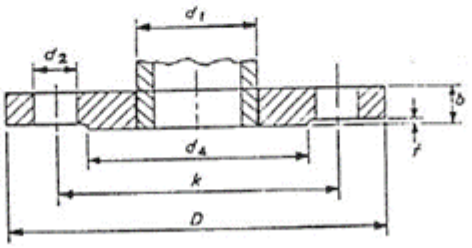
NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	420	38	315	3	M30	12	33	355
550	558,8	835	78	680	4	M45	20	48	740
600	609,6	890	84	735	5	M45	20	48	795
650	660,4	945	90	790	5	M45	24	48	850
700	711,2	995	96	840	5	M45	24	48	900
750	762,0	1080	102	900	5	M52	24	56	970
800	812,8	1140	108	960	5	M52	24	56	1030
900	914,4	1250	120	1070	5	M52	28	56	1140
1000	1016,0	1360	132	1180	5	M52	28	56	1250
1100	1118,0	1460	142	1280	5	M52	32	56	1350
1200	1220,0	1575	154	1380	5	M56	32	62	1460
1300	1320,0	1685	166	1490	5	M56	32	62	1570
1400	1420,0	1795	178	1600	5	M56	36	62	1680

- 7 -

NWS 1676 REVISION O

TABLE 6

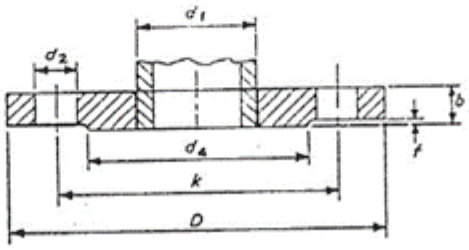
STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 64/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE 6,4 MPa



NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	440	50	315	3	M33	12	36	370
450	457,2	715	84	560	4	M39	20	42	630
500	508,0	800	94	615	4	M45	20	48	705
550	558,8	855	102	680	4	M45	20	48	760
600	609,6	930	108	735	5	M52	20	56	820
650	660,4	985	116	790	5	M52	24	56	875
700	711,2	1045	124	840	5	M52	24	56	935
750	762,0	1100	132	900	5	M52	24	56	990
800	812,8	1165	140	960	5	M56	24	62	1050
900	914,4	1285	156	1070	5	M56	28	62	1170
1000	1016,0	1415	172	1180	5	M64	28	70	1290

TABLE 7

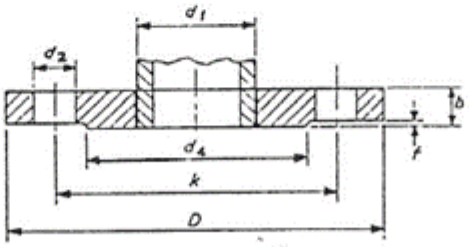
STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 100/3 OF BS4504:PART 1:1969
NOMINAL PRESSURE 10,0 MPa



NOM. SIZE	PIPE OD	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	475	66	315	3	M36	12	39	400
450	457,2	770	112	560	4	M45	20	48	675
550	558,8	935	134	680	4	M56	20	62	820
600	609,6	990	144	735	5	M56	20	62	875

TABLE 8

STEEL PLATE FLANGES FOR WELDING
CONSISTENT WITH, BUT NOT COVERED BY,
TABLE 160/3 OF BS4505:PART 1:1969
NOMINAL PRESSURE 16,0 MPa



NOM. SIZE	PIPE OF	FLANGE		RAISED FACE		BOLTING	DRILLING		
	d_1	D	b	d_4	f		No.	d_2	k
225	246,1	475	84	315	3	M36	12	39	400

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

PART C3.2
TCTA MODULAR STANDARDS

SECTION 29

HYDRO-MECHANICAL PLANT

PART C3.2
TCTA MODULAR STANDARDS

SECTION 29
HYDRO-MECHANICAL PLANT

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SECTION 29
HYDRO-MECHANICAL PLANT

29.1 SCOPE

This Section covers:

a) The design, supply of all materials, manufacture, shop assembly and testing, corrosion protection, delivery, off-loading on Site, storage and installation at Site, Site painting and pre-commissioning of the all the Hydro-Mechanical Plant:
   i) Radial Scour Gates (hydraulically operated);
   ii) Stop Logs) (manually operated);
   iii) Sluice or Channel Gates (hydraulically or electrically operated);
   iv) Trash Racks (manually operated);
   v) Fine Screens (manually operated);
   vi) Trash skip; and
   vii) Access ladders, walkways and platforms for operation and maintenance purposes.

b) The conceptual design drawings prepared by the Employer to outline the general requirements of the gates and screens. The Contractor shall develop the design of the Plant within the space and layout constraints indicated by the conceptual design drawings and in accordance with the Contract.
   The design shall take into account, inter alia, all the operating and maintenance requirements and physical and climatic conditions at the Site.

c) The supply of the Plant with all necessary items to provide complete working installations including all built-in parts and anchors, rail tracks, covers and frames, operating gears, control, monitoring and safety devices, actuators and electrical control panels from and including the main isolating switch on the incoming supply.

d) The manufacturing, testing and inspection of all Plant components.

e) All construction work in forming and preparing box outs chases etc., to receive the built-in parts and in placing concrete around them or grouting-in base plates and holding down bolts and the like. It also includes the complete installation of all Plant components to make them fully operational.

This document shall be read in conjunction with Section 28 – Mechanical General, Section 37 – Painting and Corrosion Protection and Section 48 - Tests on Completion to Contract End. This Section takes precedence over Section 28 – General Mechanical.

29.2 DEFINITIONS, REFERENCES AND STANDARDS

29.2.1 Definitions

For the purpose of this Section:

a) **“Manual Operation”** shall refer to the handling, removal and (re)installation of the Plant by means of a grapple, crane and/or hoist (local).

b) **"Pre-commissioning"** shall refer to the functional field test done on specific part of Plant on Site. This forms part of Test on Completion as specified in Section 48.

c) **"RL"** means reduced level in metres.

d) **"Water path"** shall refer to the distance along the surface of a material embedded in concrete but exposed to water measured from the concrete surface.

e) **"Wet"** refers to permanently or usually "buried", "submerged", "submersed" or "immersed" conditions and shall include internal of valve chambers and other dry but normally very humid condition.

29.2.2 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHS Act 85 of 1993, Construction Regulation 2014, Electrical machinery Regulation, Electrical installation Regulation, Pressure equipment Regulation, Driven machinery Regulation Lifting and SANS 10085.

29.2.3 Standards

The following Standards and Codes of Practice are relevant to his Section:

German Institute for Standardisation

DIN 19074: Part 1	:	Criteria of Design and Calculation
DIN 19704: Part 2	:	Design and Manufacturing
DIN 19704: Part 3	:	Electrical Equipment

South African National of Standards

SANS 121	:	Hot-dip galvanised coatings on fabricated iron and steel articles
SANS 142:2012	:	Narrow Elastic Fabrics and Strip
SANS 1431	:	Weldable Structural Steel
SANS 1700	:	ISO metric precision hexagon-head bolts, screws and nuts (coarse thread medium fit series)
SANS 3581: 2008	:	Welding Consumables for manual metal arc welding of stainless steel and heat resistant steels
SANS 10044	:	Welding
SANS 10162-4:1997	:	The Design of Cold-formed Stainless Steel Structural Members
SANS 50028-7: 2005	:	Flat Products made of Stainless Steel for Pressure Purposes

American Water Works Association

AWWA C513 : Open-channel, Fabricated-metal Slide Gates

American Petroleum Institute

API 1104 : Standard for welding pipelines and related facilities

British Standards Institution

BS 4677: 1984 : Arc Welding of Austenitic Stainless Steel Pipework for Carrying Fluids

South African Electrolytic Corrosion Committee

Code of Practice No. SAECC/1

ANSI B31.3: Process Piping

ISO 3302: Dimensional Tolerances

29.3 REQUIREMENTS

29.3.1 General

a) The Engineer shall be allowed and assisted by the Contractor to conduct full quality control during manufacture and installation. After installation at Site, all gates, racks and screens shall be commissioned by the Contractor in the presence of the Engineer.

b) All lifting equipment required for the installation at Site shall be provided by the Contractor. The Contractor shall supervise the off-loading of the Plant at Site.

c) During installation, proper care shall be taken to facilitate alignment and matching of corresponding surfaces as well as drop tight sealing of each gate against its sealing frame when the gates are in a closed position.

d) The bottom sealing face of the sealing frame shall allow for unobstructed flow without allowing stones or other debris to gather in the sealing frame or on the sealing face.

e) The gate design shall include rubber seals, which shall be from EPDM rubber or equal.

f) The gates shall be guided to limit their motion to the up and down direction only. In each, the design of the sluice gates shall include devices to positively locate the gate in the guide frames, preventing it from dislodging in any direction. Sufficient load bearing surfaces shall be provided. The tandem shaft and spindles must be utilised to ensure alignment of the slide as it is raised or lowered.

g) The gates shall be designed to operate in fully submerged conditions during normal operation.

h) The gates shall be able to operate at any head up to the maximum and at any opening between fully open and fully closed.

i) During operation, the bottom of the gates (slides) shall be at the same level as the top of the opening when in the fully raised position allowing unobstructed flow through the gateway.

j) The gates shall be installed in such a manner that the skin plates shall always be on the wet side when in the closed position.

k) The complete channel gate assembly shall be fabricated from stainless steel grade 316L or better and corrosion protected as specified in Clause 29.11 of this Section.

l) The gates shall be clearly identified with the manufacturer's nameplates giving Contract No., year of manufacture, sluice no., mass in kg, maximum hydrostatic head, material used and all necessary information relating to the supply and replacement parts. These nameplates shall be manufactured from stainless steel, mounted on the sluice gate by means of stainless steel screws or stainless steel rivets.

m) After manufacture (but before dispatch) the gate (complete with all associated and contiguous components including waterway liners) shall be fully assembled in the workshop to allow for witnessed, comprehensive fit-up and operational checks by the Engineer.

29.3.2 Radial Scour Gates

The Radial Scour Gates shall be used to scour the traps. The gates shall be operated by hydraulic cylinder for which the hydraulic power shall be supplied by a power pack situated in a local Control Room which will service all the radial and channel gates in the sediment canals and traps. Stoplog grooves shall be provided in the concrete wall upstream as well as downstream of the Radial Scour Gates as indicated on the drawings.

The Radial Scour Gates shall be supplied with hydraulic cylinder, built in parts, hoist beam, control gear and operating Plant:

a) The radial gate shall close a clear opening as indicated on the drawings;

b) The gate skinplate shall have a radius of 6 m;

c) The trunnions shall be situated 4 m above the sill level;

d) One double acting hydraulic cylinder shall be used and shall be attached to the centre of each gate;

e) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with sufficient force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose;

f) The gate structure shall be manufactured from 3CR12 except as provided for below and painted according to Clause 29.11;

g) The gate shall be able to operate at any head up to the maximum differential head and at any opening between fully open and fully closed. The minimum opening shall be specified by the designer but shall not be more than 150 mm from the sill;

h) The opening and closing speed of the gate shall be approximately 0.5 m/min;

i) The trunnion bearings shall be self-aligning;

j) A dogging device shall be provided to lock the gate in the raised position. The pin shall be lockable in the fully extended and retracted position;

k) The dogging device shall be hydraulically interlocked with the main cylinder to prevent lowering of the gate in the dogged position;

l) The skinplate of the gate shall be of pickled and passivated Grade 316L stainless steel;

m) The vertical side plates of the gate shall be manufactured from stainless steel Grade 316L if they are closer than 300 mm to the side walls;

n) The gate shall have an upstream sealing arrangement to seal off the opening as indicated on the drawings;
o) A seal wetting system shall be supplied to lubricate the seals of the gate during dry operation. This system shall be manually selected on the control panel when required;
p) The sealing and sliding surfaces shall be of Grade 316L stainless steel;
q) The guide rollers shall be situated downstream of the side seals;
r) Sealing shall be as specified in Clause 29.6.4;
s) The controls are specified in Clause 29.99; and
t) The hydraulic system is specified in Clause 29.1011.

29.3.3 Sluice Gates

The Sluice Gates shall be used to scour sediment traps, to isolate the sedimentation canals or traps or to control flow, as per the proposed operation and control philosophy, and shall be operated using a hydraulic cylinder and control gear for which the hydraulic power shall be supplied by a power pack situated in a local Control Room .

a) Sluice gates shall be provided to seal off clear openings as indicated on the drawings and seal the traps or canals as required by the operating and control philosophy.
b) The design water head above the sill and maximum hydrostatic head on the gates shall be as indicated on the drawings and will operate under all river flow and flood conditions as required by the Work's operating and control philosophy and at any opening between fully open and fully closed.
c) Sluice gates shall be controlled by hydraulic cylinders attached to the gate and mounted above each gate. One only double acting hydraulic cylinder shall be used on flow control sluice gates and shall be attached to the centre of the gate
d) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with sufficient force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose.
e) Where local operation is required for scouring purposes, each sluice gate shall be manually controlled by a single vertical electrical actuator mounted above each gate and accessible from an operating platform / walkway adjacent to the gate.
f) Each gate shall be operated using a mobile lever operated 3-way directional control valve with P to T open to tank. The valve to be mounted at handrail height at the operating platform at each cylinder (gate).
g) The minimum opening for flow control sluice gates shall be specified by the designer but shall not be more than 150 mm from the sill.
h) The opening and closing speed of gates shall be 0.5 m/min.
i) Dogging devices shall be provided to lock gates in the raised position. The pins shall be lockable in the fully extended and retracted position.
j) The dogging devices shall be hydraulically interlocked with the main cylinder to prevent lowering or raising of the gate in the dogged position.

k) A seal wetting system shall be supplied to lubricate the seals of the gate during dry operation. This system shall be manually selected on the control panel when required.
l) The gates shall be manufactured from 3CR12 except as provided for below and painted according to according to Clause 29.11.
m) Each sluice gate shall slide in built-in stainless steel 316 L guides.
n) Gate wheels shall be manufactured from Grade 316L stainless steel.
o) The bottom edge/sill of the gate shall be of stainless steel Grade 316L.
p) The design and installation procedure shall make provision for installing the gate and frame as a unit to ensure proper alignment.
q) Where gates are installed across adjacent sediment canals and traps, gate installation shall ensure that the centre of gravity of all adjacent gates are in line in order to facilitate the use of a single overhead crawl beam common for all the sluice gates during maintenance procedures.
r) The gate shall be guided to limit its motion in the up and down direction only. The design of the sluice gate shall make provision for devices to positively locate the gate onto / into the guide frames, preventing it from dislodging in any direction. Sufficient load bearing surfaces shall be provided.
s) The sluice gates in fully raised position shall clear the full opening to allow unrestricted flow.
t) Sealing shall be as specified in Clause 29.6.4.
u) The controls are specified in Clause 29.99.
v) The hydraulic system is specified in Clause 29.1010.

29.3.4 Stop Logs

a) Stop logs for the Boulder and Gravel Scour Traps or Canals to be designed that it can be stacked in order to obtain the required height and limit the weights for it to be handled by the Portal Crane (Boulder and Gravel Scour Canals) which will place it in position.
b) The design of the Boulder and Gravel Scour Trap or Canal stop logs' sealing arrangement to allow for stacking of the stop logs.
c) Boulder and Gravel Scour Canal Stop logs must be able to be stacked in any possible sequence.
d) Stop logs be manufactured from mild steel and painted according to Clause 29.11.
e) The stop logs must be transportable by means of a heavy vehicle.
f) Stoplogs shall have a lifting device for handling by the portal crane (Boulder and Gravel Scour Canals) or lifting device fitted to a crawl beam or monorail.

29.3.5 Trash Racks and Fine Screens

29.3.5.1 General

a) The purpose of the trash racks and fine screens are to screen water entering the sedimentation traps. The trash racks used to prevent large floating debris from entering the Gravel Scour Traps or canals.

b) The racks and screens shall have maximum opening to prevent debris and silt from entering pump sumps with rack and screen dimensions as specified. The racks and screens shall be sized to prevent debris and silt entering the pump sumps that would be in excess of the particle size that can be handled by the selected pumps and pipework.
c) Raising and lowering of the racks and screens shall be manually controlled by a grapple beam suspended from the portal crane or crawl beam and accessible from an operating platform / walkway adjacent to the rack or screen.
d) Separate trash rack units will be stacked directly on top of other in guides installed in the Diversion structure and shall cover the full height up to the operating deck level.
e) Four operational sets shall be supplied.
f) The trash racks and screen panels shall be designed as fixed, light weight interchangeable Grade 316 L stainless steel units, typically as indicated on the drawings.
g) All supports required to keep the trash rack and fine screens rigidly in position shall form part of the supply.
h) The racks and screens shall be manually cleaned by means of raking or after being lifted onto the operating deck.
i) Corrosion Protection according to Clause 29.111.

29.3.5.2 Rack and Screen frames

a) The trash racks and fine screens shall have frames manufactured from stainless steel Grade 316L sections, manufactured from rolled plate.
b) Each frame shall be fitted with four parallel guide stubs manufactured from Nylatron GSM which shall slide freely in the guides as indicated on the drawings. Guide stubs shall be mounted close to the corner on the vertical sides of the frames and are not required to rotate.
c) Special care shall be taken to ensure that the fully assembled racks and screens are flat and that the sides of the frames are square and parallel to one another. The squareness tolerance of ± 2 mm diagonally across corners and the flatness tolerance of 2 mm shall be strictly adhered to..
d) Each frame shall have debris collecting trays on at least two different levels on its upstream side which shall prevent any debris from falling down to the bottom of the screen and canal.
e) Water shall drain freely from the screen frame and trash collecting trays.
f) Each frame shall be designed in such a way that it can only be installed in the guides in the correct orientation.
g) All supports required to keep the trash rack and fine screens rigidly in position shall form part of the supply.
h) The maximum height of a trash rack shall not exceed two meters to facilitate easy cleaning.

29.3.5.3 Screen slats

a) All slats shall be manufactured from stainless steel Grade 316 L and shall fit accurately into the stainless steel frame.
b) Slats shall be vertically mounted.

c) All sections shall be homogeneous and free of any defects, burrs or flaws and shall have a smooth surface.

29.3.6 Trash Skip

a) A trash skip with lockable steel wheels shall be supplied, capable of being hand-manoeuvred on the deck, above the gravel and sand traps when filled with trash. The wheels shall be suitable for extended periods of exposure to the elements without suffering any material or lubrication degradation.
b) The trash skip shall be of 4 m^3 capacity and manufactured from a robust 304L steel construction and rubber lined.
c) The trash skip shall be equipped to be emptied onto a road vehicle by using the portal crane.
d) Proper provision for drainage of water shall be made in order to keep down the weight of the trash filled skip.
e) Corrosion protection according to Section 37 – Painting and Corrosion Protection.

29.3.7 Permissible Stresses

Permissible design stresses shall comply with the requirements as specified under Section 28 – Mechanical General.

29.4 BUILT IN PARTS

29.4.1 General Requirements

a) Those parts of the Works that are required to be built into the concrete structure with precision (e.g. base plates, frames etc.), are referred to herein as "second stage built-in parts".
b) In order that the second stage built-in parts may be rigidly supported during construction, installation, they shall be secured by means of adjustable bolts and the like to anchors, ties, etc., already incorporated into the structure. These anchors, ties, etc., are referred to herein as "first stage built-in parts".
c) First stage built-in parts shall be built into the structure by the Contractor in accordance with drawings and information supplied by the manufacturer of the Hydro-Mechanical Plant.
d) The Contractor shall ensure that the manufacturer of the Hydro-Mechanical Plant signs off on the process for checking that the parts are built in by the Contractor with sufficient accuracy to comply with the designed functional requirements. First stage built-in parts shall have not less than two 6 mm diameter holes (suitably spaced) drilled in them so that the parts may be bolted or nailed to formwork to hold them securely in position during first stage concreting.
e) The Contractor shall be responsible for the design, detailing and accuracy, manufacture, corrosion protection, trial erection, transport, storage and supervision of embedding in first stage concrete of first stage built-in parts. The Contractor shall ensure the correctness of the line and level of such parts before (and checked after) the concrete has been placed. The Contractor shall nevertheless ensure that first and second stage built-in parts are designed and manufactured in such a way that adjustment is possible between the first stage built-in parts and second stage built-in parts to allow precise setting of the latter.

f) Special attention shall be given to the safe installation of these items, taking into consideration that safe temporary working platforms and safety harnesses will be required as well as any other safety precaution as stipulated in Section 2 - Occupational Health and Safety.

g) All first stage anchor plates for building into the primary concrete shall be provided timeously according to the approved programme. All second stage anchor bolts/bars and adjusting nuts shall be provided for the gate sealing frames and guide sections.

h) Second stage anchor bolts/bars shall be a minimum of 16 mm diameter and shall be welded to the anchor plates to enable accurate adjustment and alignment of the frame and guide sections to be made. The anchors shall be arranged to ensure that no movement of the members occurs during placing of the secondary concrete around them. The design of first and second stage built-in parts shall reflect the forces that will be applied to them in service. In the case of heavily loaded first stage built-in parts, anchor rods shall not be “spot” welded to plates but set into holes drilled through the plates and then welded on both sides (or secured by such other means as are acceptable to the designer and Engineer).

i) All welds on built-in parts, including those between adjusting bolts and first stage anchors, shall be adequate to develop the full strength of the abutting members in order to resist separation of the built-in parts from the surrounding first and second stage concrete and of the adjusting bolts from the first stage anchors.

j) All first and second stage built-in parts shall be arranged so as to allow the proper placing and compaction of concrete and eliminate any air voids around the embedded parts. They shall be suitably shaped to allow fixing of reinforcement in second stage concrete generally as shown on the drawings.

k) All permanently immersed built-in parts in contact with water, or where maintenance painting is not possible, shall be of Grade 316L stainless steel up to a water path of 150 mm. All parts covered in concrete but within 50 mm of the surface shall also be considered to be in contact with water and be treated as above. Nuts, bolts and washers of second stage built-in parts which will be subject to an exterior environment in the completed Works shall be stainless steel.

l) All first stage built-in parts shall be coated with a hold primer to prevent corrosion of the parts until such time that the second stage built-in parts can be erected and cast in.

29.4.2 Restriction on Time of Loading of Built-in Parts

Built-in parts shall not have any loads applied to them earlier than the latest date of either:-

a) 7 days after completion of epoxy grouting; or

b) 28 days after completion of first stage or second stage concreting in or such earlier date as may be approved by the designer; and

c) The Contractor shall ensure that under no circumstances during the casting in of any primary or secondary concrete are loads transferred to the built-in parts.

29.5 GRAPPLE

a) Automatic type grappling beams shall be used to handle the stoplogs, trash racks and fine screens by means of the portal crane and mono-rail (see Section 31 – Cranes, Hoists and Winches) on top of the deck.
b) Grappling beams for each size stop log shall be supplied. One grappling beam may be supplied to handle the trash rack and fine screens. Each grappling beam shall be designed to safely handle the heaviest of the loads that it will be required to lift.
c) Each grapple shall be suspended from the portal crane or mono rail with a single stainless steel lifting pin, designed in such a way that it will centralise the crane hook.
d) The main body of each grapple shall be 3CR12.
e) The grapple hooks shall have welded on stainless steel liners on all edges that will come into contact with the equipment being lifted or may be manufactured complete from stainless steel 2204.
f) The grapple hooks shall automatically engage into slots in the equipment being lifted when lowered onto these.
g) Each grapple shall, both in the loaded and unloaded condition, hang plumb when suspended from the portal crane.
h) When the weight of the Plant suspended is taken off the grapple hooks, the grapple shall automatically disengage from that specific piece of Plant.
i) Stainless steel resting plates shall be installed on the points of contact when the grapple rests in the unloaded condition on top of the equipment being lifted.
j) Each grapple shall run freely on Nylatron GSM or Vesconite guide rollers inside the same built-in guides as the Plant that it is handling. The guide rollers shall run on stainless steel axles and shall be an integral part of each grapple, supporting it in the direction of flow and across it.
k) When not in use, each grapple shall be stored by means of integrated stainless steel storage pins on the top end of its guides. Each storage pin shall be provided with a stainless steel lock pin to lock it either in the “storage” or “operation” position.
l) All bushes shall be stainless steel, the inside of which shall be cleared of paint after corrosion protection.
m) All pins / axles shall be of stainless steel Grade 316 or EN57.
n) To minimise maintenance, no ball or roller bearings shall be acceptable.
o) All grapple motions of the completely assembled grapple shall at all times be able to move freely, both inside and out of water.
p) The grapple shall after manufacture and assembly be straight and true to the dimensions specified by the designer.

29.6 DETAILS OF GATES

29.6.1 General

a) Gate bodies and non-detachable parts shall be welded constructions. All welds shall be continuous with no crevices.
b) The minimum thickness of the radial gate skin plate shall be 12 mm.
c) Gate (slide) shall consist of a flat plate reinforced with structural or formed members welded to the plate.
d) The gates shall be designed in such a manner that water retention areas are avoided. Where this is not possible drainage holes shall be provided to prevent water retention which shall be a minimum of 50mm in diameter. The design shall avoid areas and profiles that are difficult to paint. Where this is unavoidable the areas shall be boxed and seal welded to the satisfaction of the Engineer.
e) All edges and corners shall be radiused and polished for smooth operation within the guide seal assembly.
f) Parts that are difficult to reach after installation or that require “frequent” disassembly (as determined by the designer) shall be manufactured from Grade 316L stainless steel.
g) No threaded holes into mild steel shall be allowed. Threaded holes shall be avoided where possible and where unavoidable shall be into stainless steel 316L.
h) All axles or moving parts shall be from stainless steel Grade 316L, EN57 or other suitable corrosion resistant steel. All mating surfaces shall also be from stainless steel.
i) All bushes and bearings shall be self-lubricating or of no or low maintenance.
j) Guide rollers fitted to the gates shall be of a suitable proven corrosion resistant material and fitted with self-lubricating bearings. Should guide blocks be used instead of the rollers these shall be made of a suitable self-lubricating polymer.
k) The gate wheels shall be manufactured from stainless steel Grade 316, EN57 or better and fitted with self-lubricating bearings where possible.

29.6.2 Sealing Frames and Guides

a) Sealing frames shall consist of upstream, downstream and side guides and side-, sill- and lintel sealing members where appropriate.
b) Gate frames shall be of the self-contained embedded channel mount type.
c) Gate guides of all channel and sluice gates shall extend to operating deck level or such, that when the gates are fully opened, the bottom of the gates (slides) shall clear the opening.
d) Guides shall be designed and constructed to withstand the total thrust caused by water pressure.
e) All sealing, sliding and running surfaces shall be of stainless steel, Grade 316L or better. The sealing frames and guides shall also be of stainless steel Grade 316L plate and sections and shall be fabricated so as to give a rigid structure.
f) All sections shall be perfectly straight, flat, square and true after manufacture and corrosion protection to the dimensions given on the drawings. The straightness tolerance shall be

1 mm in 1 m to prevent unequal pressure or leakage. The squareness tolerance of ± 2 mm diagonally across the corners shall be strictly adhered.

g) All guide members of a specific set shall be bolted together in sequence at the manufacturer's works for inspection and each individual guide member shall be marked by hard stamping with corresponding numbers in order for them to be installed in the same sequence.

h) All sealing, sliding and rolling surfaces shall be smooth, with no steps or misalignment at the joints between adjacent guide sections.

i) The bottom seal shall be of the flush bottom closure type and shall be compressible rubber at the invert of the opening and extend into the side guides forming a complete seal for the entire width of the gate. The gate frame lower member shall be furnished with a specially shaped polymer seal and loading pad. The bottom edge of the gate (slide) shall have integrally formed reinforcement and have gently ramped lead-in surface to prevent damage to the seal.

j) Special attention shall be given to the aligning and adjusting of these surfaces and safe temporary working platforms and safety harnesses shall be used for installing these items in order to achieve this.

k) For any load bearing roller paths, sealing frames shall have thick stainless steel plate of adequate size to transmit the wheel loads to the supporting frame and concrete.

l) A clearance of 5 ± 1 mm shall be allowed, in the direction of flow, between the inner surfaces of each guide member and the gate / fine screen element running in it. Across the direction of flow, this lateral clearance shall be minimum 6 mm and maximum 10 mm.

29.6.3 Yoke

a) The yoke to support the operating bench stand shall be formed by two structural members welded or bolted to the frame extensions to form a one piece rigid frame.

b) The yoke shall be fabricated from stainless steel grade 316L and all fasteners shall be stainless steel grade 316.

c) The gate (slide) shall be removable through the yoke opening or by disassembly and removal of the yoke.

d) Yoke members shall be designed for maximum output of the gate hoist mechanisms.

29.6.4 Seals

a) The gate shall be provided with appropriate sealing to ensure that when the gate is in a closed position against maximum water pressure, leakage past the seal shall not exceed 0.1 ℓ/sec/metre seal length.

b) All seals shall be easily replaceable without having to remove the gate (slide).

c) Corners or intersections of seals and bearing strips shall be prefabricated to ensure they are interlocked and sealed.Seal corners shall be pre-moulded with no joints at or within 200 mm of a corner. in order to provide leak-proof joints

d) Shop joints shall be vulcanised and shall avoid feather-edges on the sealing surface. Field joints shall be minimized, accurately machine cut, carefully butted to provide interference fits, joined by a cold curing epoxy, and held with double fasteners on each side of the joint.

e) Rubber seals and bearing strips shall be manufactured in South Africa and have the following minimum physical characteristics as tabled in Table 29/1:

TABLE 29/1
CHARACTERISTICS FOR RUBBER SEALS

PHYSICAL PROPERTIES	UNITS	MATERIAL	
		EPDM (ETHYLENE PROPYLENE DIENE MODIFIED)	NEOPRENE (HIGH STRENGTH)
Density	g/cm^3	1.2	1.47
Durometer Hardness (Shore A)		55/65	55/65
Tensile Strength: – Initial – After aging 14 days at 70°C in air	MPa %	10 < -20%	10 < -20%
Tear Strength: – Initial – After aging 14 days at 70°C in air – Elongation at break	MPa % %	>10 < -20% > 350	>10 < -20% >300

Bearing Strips:

i) Material : Ultra-high Molecular Weight Polyethylene (UHMW-PE).
ii) Specific Gravity : 0.93.
iii) Tensile Strength : 21.4 MPa.
iv) Water Absorption : 0.01% (in 24 hrs).
v) Elongation at break : > 300%.
vi) Shore hardness : 62 – 66.
vii) Coefficient of Friction : 0.15 – 0.20.

f) Dimensional tolerance of the seals shall comply with ISO 3302, unsupported extrusion class E2.

g) Normal dimensions:

- 10 to 16 mm : ± 1 mm
- 16 to 40 mm : ± 1.3 mm
- 63 to 100 mm : ± 2 mm

h) The lashing strips shall be clearly marked (numbers to be welded on) to indicate their correct position relative to the gate - hole alignment. The bolt holes in the seals shall be drilled in the

factory and the seals shall be marked to indicate their correct position with respect to alignment of holes.

i) The lashing strips shall be manufactured from stainless steel grade 316L and shall not join at the same points as that of the rubber seal joints.

j) All bolts and fixings for the seals shall be stainless steel grade 316. Countersunk head screws shall be of the Allen key type. 1 mm thick Nylon 6E washers shall be used under all countersunk screw heads. Dubo washers shall be used under washers and nuts.

29.6.5 Channel Gate Operating Gear Mechanism

a) Operating gearboxes (both drive and driven gearboxes) shall be secured to the top of the head frame bridge (yoke) with actuator approximately 1000 mm above the operating floor level.

b) The two lifting geared mechanisms shall be interconnected via a tandem shaft manufactured from stainless steel grade 316L. Shafts, gears and other rotating components shall be supported on heavy-duty roller bearings to provide the highest possible efficiency. All bearings and gears shall be totally enclosed in weather tight housings and provided with a seal on the input shaft of the gearbox to prevent water from entering the gearbox.

c) Geared operating mechanisms shall be furnished with a threaded bronze lift nut to engage the threaded portion of the rising spindles.

d) An electrically operated gearbox shall be provided with a gear ratio as required to ensure a rim pull at the handwheel of the actuator of between 100 and 150 N under full unbalanced head.

e) Each slide gate shall be equipped with two rising operating spindles (stems) manufactured from stainless steel grade 316L with ‘Acme’ threads and shall be provided with adjustable stop collars to limit upward and downward travel after final installation and adjustments. After final adjustments of the stop collars, they shall be locked in position by means of stainless steel grub screws which shall fit into a drilled indentation in the operating spindles. Collars shall be fabricated from bronze or FRP bushing.

f) Spindles shall have a slenderness ratio (L/R) less than 200.

g) Linear position indicators shall be incorporated in the rising spindles weather protection column, indicating the position of the channel gate in 10% increments, from fully open to fully close.

h) Closure of the gates shall be through the clock-wise rotation of the actuator handwheel.

i) The direction of handwheel rotation to open and close the gate together with directional arrows shall be legibly cast in on the upper surface of the rim on the handwheel.

j) Provision shall be made for easy lubrication of the operating mechanism. Operation of the sluice gate must not be adversely affected by extended exposure to the elements and alternating dusty and humid conditions. Refer to Section 28 – Mechanical General for further details on the requirements of lubrication.

29.7 MANUFACTURING

29.7.1 Material

The materials for manufacture shall be as follows:

Gate (Slide)	:	Stainless Steel Grade 316L.
Sealing Frames/Guides/Yoke	:	Stainless Steel Grade 316L.
Operating Tandem and Spindles	:	Stainless Steel Grade 316L.
Fasteners	:	Stainless Steel Grade 316.
Operator Housing	:	Cast Iron SANS 936/937 Grade SG42 or Cast Steel to BS EN 10293.

For additional corrosion protection of various components refer to Clause 29.11.

Welding electrodes for stainless steel shall be of austenitic stainless steel grade 316 or as recommended by the material manufacturer and a welding authority acceptable for the Engineer.

All fasteners used for the Plant shall be stainless steel grade 316. All surfaces on fasteners shall be smooth and without jagged edges. They shall be pickled and re-passivated after machining.

All material and Plant, where not specified, shall comply with relevant SABS or BS Standards.

All materials and Plant shall be new and of first grade quality.

All bronze shall be zinc free.

29.7.2 Drilling

All bolt holes, made during manufacture or on Site, shall be drilled, not punched.

29.7.3 Cutting

Edges of all plates and structural members shall be square, clean and free from burrs and true to dimensions. If flame/plasma cutting is employed, resultant edges shall be dressed smooth and true.

29.7.4 Bolts and Nuts

All bolts, nuts and washers shall be of stainless steel grade 316 (A4 to EN 3506) and shall comply with Section 28 – Mechanical General.

29.7.5 Welding

Welding shall be in accordance with BS and SANS Standards for non-corrosive steel and shall be in accordance with Section 28 – Mechanical General. The Contractor shall satisfy the Engineer that his welders are qualified in accordance with the welding specifications.

29.8 STORAGE, HANDLING AND TRANSPORT

The Contractor shall be responsible for the supervision of all loading and unloading procedures.

The Contractor shall comply with Driven machinery Regulation lifting equipment, Construction Regulation 28 - Stacking and storage.

Coated components shall be handled with due regard for the relatively soft nature of organic coating and the appropriate precautions shall be taken.

The use of ropes, wire ropes or chains without suitable padding is expressly forbidden.

The Contractor shall provide all the necessary timber and sawdust bags used to support the components on soil, concrete or other hard surfaces and to separate them from each other, both at his Works and on Site.

When loading on to vehicles, precautions shall be taken to support and chock the components to prevent movement. Components shall be firmly lashed or chained with padded lashing, supported on sawdust bags. The area of padded surfaces shall be adequate to prevent damage to the coating.

Stainless steel components shall be packed in a way that prevents contamination during transportation.

Storage, handling and transport of Plant shall further be in accordance with Section 28 - Mechanical General.

29.9 ELECTRICAL CONTROLS AND PLANT

29.9.1 Control Desk

The gates shall be controlled by a PLC and SCADA system (remote) and control panel (local) as required in terms of operation and control philosophy.

The Control Desk shall consist of one complete set of controls and indicator lights as described below, as well as a display (HMI) unit. The display unit shall be used to access the service mode of the gates, to provide information as to what operation is underway, as well as to indicate the gate opening. The unit shall also display information concerning any fault that may occur and what may be done to remedy the situation.

Manufacture may only commence once the Engineer has reviewed the layout.

29.9.2 Controls of the Gates

a) The gates shall be controlled from local control desk(s) situated in a local Control Room(s) at the Abstraction Works or remotely from a SCADA screen situated at the Scheme Control Room. The emergency stop pushbutton on the control desk and emergency close input from the SCADA screen shall override all modes of operation.
b) Emergency close input from the SCADA screen shall override all actions and close the gate even when the gate controls are in the local position. All subsequent operating commands on the gate shall require that the emergency command be cleared first.
c) All the gates shall be controlled and operated from local control desk(s). Each control desk shall have its own hydraulic powerpack.
d) All controls shall be such that once the motion has been initiated it shall continue, even when the button is released. The continued motion of the gate, once the motion has been initiated, shall be automatically arrested at both the fully raised and fully lowered positions by limit switches. It shall be possible to change the direction of gate travel at any point of travel by pressing the STOP button first.
e) The open and close commands shall be provided with interlocks that prevent simultaneous initiation or the reversal of a given motion without the STOP button being pushed.
f) The key locks on all the control panels shall use the same key. Two keys for each type of lock shall be provided.

29.9.3 Control Panel (Local control)

The control panel shall have one complete set of controls and indicator lights, as listed below, for operation of a gate.

29.9.3.1 Controls and indicator lights

a) The whole control desk shall be lockable by a key-switch. The key shall be trapped in the UNLOCK position.
b) A key operated local / remote selector switch. The key shall be trapped in the local position.
c) One 400 V voltmeter with 4 position switch to indicate the potential over each phase.
d) One ammeter with 3 positions to indicate the current in each phase.
e) A RED coloured LAMP TEST button. This button shall be labelled accordingly and shall illuminate all the indicator lamps on the control desk when depressed.
f) A GREEN coloured push button shall be provided and labelled RAISE.
g) A GREEN coloured indicating light shall be provided and labelled RAISING. This indicating light shall illuminate only when the gate is opening.
h) A GREEN coloured push button shall be provided and labelled LOWER.
i) A GREEN coloured indicating light shall be provided and labelled LOWERING. This indicating light shall illuminate only when the gate is closing.
j) A RED coloured push button switch shall be provided and labelled STOP. This button shall arrest the movement of the gate and hold it stationary in that position.

k) A 50 mm diameter mushroom headed RED coloured emergency stop push button switch shall be provided and labelled EMERGENCY STOP. This switch shall be the push to latch – twist to release type. In the operated or pushed in position, the contacts of the switch shall break the circuit of the main contactor supplying all the circuits of the gate. This main contactor shall be on the supply side of the up and down motion operating circuit.
l) A RED coloured indicating light shall be provided and labelled SYSTEM UNAVAILABLE. This light shall illuminate when there is a fault with the system.
m) A digital position indicator linked to the limit switches displaying whether the gate is in an open or closed position.
n) A position switch to select the required gate set. Each position to be labelled according to the gate set selected.

29.9.4 Sensors

29.9.4.1 Limit switches

a) For gates operated by hydraulic cylinders, limit switches shall be used only for the position indication of the lowered and raised positions. The control of the movement shall be by means of pressure switches.
b) The upper limit switch shall be made when the gate is raised, and the lower limit switch shall be made when the gate is in the lowered position.

29.9.5 Position Indicator

Position indication is not required for this Contract. When required it shall comply with the following requirements:

a) The position indicator shall be sealed to at least IP 68; and
b) Position indication to be accurate to the nearest 10 mm of gate opening.

29.9.6 PLC Interface

PLC I/O interface shall be as shown on the drawings and I/O Schedule. Provision shall be made for position indication and remote control.

A terminal strip with potential free contacts for remote indication shall be provided as follows:
a) Ready;
b) Remote selected;
c) Local selected;
d) Gate select;
e) Pump running;
f) Open gate;
g) Gate opened;
h) Close gate;
i) Gate closed;

j) Emergency close;
k) High oil pressure; and
l) High temperature.

A 4 -20 mA position indication signal shall also be wired to this terminal strip.

29.10 HYDRAULIC OIL PLANT

The hydraulic Plant shall comply with BS 4575. The control and hydraulic Plant shall be neatly mounted in a desk type panel.

The hydraulic diagram and operating instructions shall be engraved on a stainless steel plate(s). All engravings shall be filled with black paint. This plate(s) shall be permanently fixed to a wall near the gate controls. The diagram shall not be smaller than A2 size and must be reviewed by the Engineer before manufacture.

29.10.1 Hydraulic Oil Reservoirs, General

a) Hydraulic oil reservoirs shall be of welded construction and all parts, wherever possible shall be manufactured from 304L stainless steel. Return oil shall be filtered prior to re-entering the reservoirs.
b) A removable lid, incorporating a watertight filler cap, shall be fitted to the reservoir and sealed with a gasket. See through inspection covers on the sides of the tank shall be provided for cleaning.
c) The capacity of the reservoir to normal top oil level shall be not less than twice (2x) the maximum cylinder capacity.
d) The reservoir shall be mounted on an angle iron support frame, 150 mm minimum from the wall, with stainless steel 304L legs fixed to the floor with M16 stainless steel wedge anchors.
e) The reservoir bottom shall slope 1% minimum with a drainpipe and transparent glass water trap at the lower end. The water trap shall be fitted with a stainless steel ball valve, 250 mm minimum from floor level for draining purposes and sealed with a taper plug.
f) A purpose built drip tray shall be supplied below the power pack and reservoir in order to catch any fluid spilled during servicing and minor breakdowns.

29.10.2 Hydraulic Oil Reservoirs, Plant

Hydraulic oil reservoirs shall be provided with:
a) A hydraulic fluid level indicator, mounted on the reservoir in such a way that it is clearly visible whilst working on the control panel. The minimum level, with all hoist cylinders extended, shall be indicated with a red line. The maximum and filling levels shall also be indicated and appropriately marked;
b) A low oil level alarm and pump motor trip;
c) A breather fitted with a 3 micron air filter having:
    i) A flow capacity to maintain atmospheric pressure within the reservoir at maximum system demand; and

ii) A breath-out by-pass.

d) High oil temperature alarm and pump motor trip;

e) A mini mess point connected to the tank return pipe for oil sampling; and

f) A separately pumped oil filtration and cleaning system shall be mounted to the reservoir. It shall filter the oil to 3 microns and remove the water entrapped in the oil. This system shall be connected to the bottom of the reservoir in the same manner as the pump suction line and have a return line on the opposite side. The system shall work on a timer to automatically clean the oil during long periods of no operation.

29.10.3 Hydraulic Oil Reservoirs, Connections

a) The oil draw-off connection shall be mounted horizontally not less than 150 mm above the base of the reservoir.

b) The filling connection shall be arranged such that oil may only be placed in the hydraulic reservoir via the filtration system.

c) Pipe and other connections to reservoirs shall be welded internally and externally.

d) Facings and tappings shall be provided where necessary for mounting instruments and other devices. Seals shall be compatible with the operating fluids for the full temperature range. The stainless steel pads shall be welded internally and externally to the reservoir walls.

e) A solid stainless steel manifold block shall be attached to the reservoir and all valves, filters and instruments shall be directly bolted to parts in the manifold. The only pipework permitted will be the connections between the pump and manifold block. It shall be possible to remove the manifold block, as a compete unit, from the hydraulic reservoir.

f) The manifold block shall be machined on all faces to which valves and other components are bolted so that no distortion is caused either in the manifold or valve component when assembled.

g) Pipe connections, clamps and fasteners for sub-plates, valves and all parts of the hydraulic system shall suit and be accessible by standard tools to allow proper assembly and dismantling of an item without the necessity to disturb or remove any other component or pipe.

29.10.4 Filtration

a) Full flow filters shall be inserted in each hydraulic circuit.

b) The filters shall be of the full synthetic type.

c) The filter shall have an outer spiral wrapping bonded to the filter element.

d) Each hydraulic circuit shall include a 3 micron pressure pipe filter with a minimum beta value of 1000.

e) All filter elements and bodies shall be suitable for the maximum circuit pressure including transient pressures.

f) All filter elements shall be the same size.

g) All filters shall be constructed and installed so that the filter elements may be changed without disturbing pipework and/or components and with minimal loss of oil.

h) All filters shall be fitted with inbuilt clogging indicators.

29.10.5 Hydraulic Pipework

a) Pipes for hydraulic power transmission and hydraulic control circuits shall be manufactured from seamless cold drawn stainless steel tubing.

b) Where the materials to be joined are suitable and where the joint is unlikely to require dismantling for any purpose the pipe joints shall be welded. Wherever possible welded joints shall be factory fabricated.

c) All couplings shall be of the double ferrule or compression type and of the same material as the pipes to be joined.

d) Compression couplings shall conform to BS 4368 and shall not be fitted closer to the start of a bend than four times the outside diameter of the tube being joined. Compression couplings shall be tightened in accordance with the manufacturer's fitting instructions.

e) Quick release self-sealing couplings shall be leak proof under positive and negative pressures and shall be provided with a screw-on dust-tight cap manufactured from the same material as the coupling body. Where appropriate an anti-seize lubricant shall be applied to dust cap threads.

f) Joints in pipework shall be located so that any length of pipework can be removed without disturbing other pipework.

g) All flanges and coupling bolts shall be manufactured from corrosion resistant material compatible with the pipe, operating pressure, temperature and fluid. Flanged joints shall be arranged such that sealing faces are not damaged or distorted during coupling or re-coupling of the joint.

h) The ends of all pipes which are to be coupled using compression fittings shall be suitably rounded to prevent damage to the O-ring seals during assembly of the couplings.

i) Hydraulic pipework shall be designed for the appropriate operating pressure, including transient positive and negative surges, together with all gravitational, thermal and inertial forces.

j) All pipework, valves, joints, couplings, fittings and seals shall be compatible with the operating and flushing fluids used, for the full range of operating temperatures.

k) Where practicable, hydraulic systems shall be prefabricated and brought on to Site cleaned, complete and sealed.

l) Pipe runs, where appropriate, shall be designed for temperature variations and differential structural or plant movement. Movement as required shall be permitted through adjacent supports which shall not damage the pipework.

m) Pipework shall be labelled as per the hydraulic diagram.

n) Supports shall also be provided immediately before and after a bend or offset and immediately before a change to flexible hose.

o) On completion each section of pipework including hydraulic equipment, valves and the like shall be subjected for a period of not less than 8 hours to a test pressure of the appropriate relief valve setting. The test pressure shall not cause any part to be subjected to more than 70% of the yield stress of that part. The system shall be leak-free throughout the test.

p) All hydraulic pipework including control, drain and return lines shall be designed as pressure lines suitable for the maximum operating pressure in power transmission lines.

q) All pipes shall be supported in properly made clamps manufactured in high density polypropylene. Clamps shall not damage the pipe and shall be designed for the size of pipe being clamped and allow, where necessary, axial movement to take account of thermal expansion. Fixing bolts shall be stainless steel.

29.10.6 Valves

a) All Plant supplied shall be from a known and reputable company with South African representatives, i.e. Vickers, Bosch, Rexroth, Parker Hannifen or equivalent.

b) All valves in hydraulic systems shall be of the highest quality. Valves shall be bolted to machined sub-plates to which pipework shall be permanently connected such that:
- Valve and sub-plates are supported on structures and not on pipework;
- Valves shall be bolted to sub-plates without causing distortion of the valve; and
- Valves shall be removed from the circuit for maintenance without disturbing the pipework.

c) As far as possible valves and pipework shall be designed such that assembly of the Plant is only possible in the correct manner.

d) Valves shall operate without vibration for all conditions of flow throughout the working range of pressure and temperature.

e) Shut-off, non-return and direction control valves shall seal off the appropriate fluid passages completely.

f) Directional control valves shall have the P port open to tank in the neutral position when possible.

g) Shut off and direction control valves shall be provided with indicators showing clearly the position or degree of opening.

h) Where appropriate, poppet valves shall be used in preference to spool valves.

i) Valves shall have mounting dimensions complying with internationally accepted standards.

j) Valves shall be clearly and permanently marked with the manufacturer's name and type and size code.

k) All hand operated valves shall be fitted with a tamper-proof locking device.

29.10.7 Pressure Relief Valves

a) Pressure relief valves shall have provision for fine adjustment and shall be fitted with a tamper-proof locking device.

b) Pressure relief valves shall be capable of discharging the maximum design flow with a pressure variation not exceeding 5 % above and below the design relief pressure.

29.10.8 Non-Return Valves

a) Non-return valves shall have head loss characteristics for all conditions of flow compatible with the inlet pressure requirements of pumps for both directions of rotation of pump drive shafts.

29.10.9 Hydraulic Oil Pumps

a) The pressure and displacement continuous rating of each pump shall exceed by not less than 20% the most onerous requirement. Pumps which may be operated with unboosted inlet shall be used.
b) Gear type pumps shall be used. Pumps shall operate without vibration.
c) Pumps shall be suitable for full load application and continuous operation after being idle for not less than 40 days, and for operation on hydraulic mineral oil at ambient temperatures between -20°C and +45°C.
d) Pumps to start up under no load.
e) Bearings and other sliding parts shall be suitable for 10 000 hours operation at the continuous rated output of the pumps.
f) Where the drive shaft emerges from the pump casing, two separate seals, each being a continuous ring, shall be provided, the outer to exclude dirt and the inner to retain oil. The seals shall be compatible with the lubricants, hydraulic oils and flushing fluids likely to come into contact with them and shall run on non-corrodible material compatible with the respective shafts. A drain shall be provided between seals and the seals shall not be subject to seizure on the running face during long periods of idleness.
g) All internal nuts and bolts shall be locked with tab washers or by other similar means.
h) Pumps shall be coupled to drive machinery in such a way that no radial or axial loads are transmitted to the pump and such that the pump does not transmit radial or axial loads to the drive machinery.
i) Pumps shall be flange mounted to equipment in such a way that a pump may be removed and then replaced without the need for elaborate re-alignment procedures.
j) Pumps shall be of proven design.
k) All hydraulic pumps shall be tested in accordance with BS 4617 Class B.
l) Back-up hand operated pumps shall be supplied for use in case of power failure. The pump shall be sized to provide the design working pressure at an input of not more than 150 N.
m) The pump lever shall be mounted horizontally in a convenient position and at a comfortable height.

29.10.10 Filling Hydraulic Circuits

a) Each part of the hydraulic circuit shall be thoroughly cleaned before, and maintained clean during assembly.
b) After assembly the whole system shall be flushed using clean flushing oil at three (3) times the normal flow rate or an airmatic system until the Contractor has demonstrated that the system is as clean as may be expected when operating with the specified standard of filtration and new filters shall be fitted prior to filling the circuit with new hydraulic oil.
c) The circuit shall be designed in such a way that it may be filled or replenished only via the filters.
d) The system shall be filled with hydraulic oil of a 14/12 cleanliness rating.

29.10.11 Flexible Pressure Hose

a) All flexible pressure hose shall be long-life multi-spiral hose.
b) Flexible hose shall be installed into the pipework system at suitable locations to take up thermal movement and at points of differential movement between adjacent structures and/or equipment and where installation of rigid pipework might transmit unacceptable loads to a particular piece of equipment. The hose shall be installed in accordance with the manufacturer's recommendations, and shall be suitable for use with the fluid being transmitted at the operating vibration frequencies, pressures and temperatures.
c) The inner tube shall be seamless and shall be wound with alternate layers of spiral reinforcement in opposite directions, each separated by a layer of suitable synthetic rubber. The outer cover shall be resistant to abrasion and weathering in the environment of the installation.
d) Flexible hose end fittings shall be factory swaged into position and shall be manufactured from the same material as the pipe onto which it fits.
e) Flexible hoses shall be installed such that:
    i) They are the correct length;
    ii) Motion is in one plane and torsional stresses are avoided;
    iii) Short radii and S-bends are avoided;
    iv) Bend radii shall not be less than 1.2 times the minimum recommended in the appropriate British Standards;
    v) They are securely supported and not subject to torsion or compression;
    vi) They do not rub against any other hose, item or structure of any kind;
    vii) They are protected against accidental damage and suitably restrained in areas where their failure might constitute a hazard;
    viii) They are easily accessible for maintenance and inspection;
    ix) Under normal working conditions that part of the hose adjacent to end fittings shall not flex for a distance equal to eight times the outside diameter of the hose; and
    x) As far as is practicable they do not run horizontally.

29.10.12 Pressure Unloading Valves

a) At each power pack a pressure unloading valve shall be incorporated in the circuit so that pumps may circulate oil to tank at low pressure when the system demand is very small.
b) The valves shall have switching pressure differentials compatible with proper operation of the equipment in the hydraulic circuit and shall be of the pilot operated accumulator charging type.

29.10.13 Hydraulic Accumulators

a) Accumulators shall be of the nitrogen over oil bag type and shall be constructed to withstand not less than 5 times the system maximum working pressure.
b) Means shall be provided for safely relieving the nitrogen pressure for dismantling the accumulator and other parts of the circuit.
c) All circuits incorporating accumulators shall have facilities for bleeding at each high point.

d) Safety manifold blocks to be supplied with all accumulators.

29.10.14 Pressure Gauges

a) Pressure gauges for use in hydraulic systems shall be of the Bourdon tube type, shall be glycerine filled and shall generally comply with the requirements of BS 1780.
b) Gauge dials shall be not less than 100 mm diameter and shall have clearly marked divisions and figures in black on a white background.
c) Scale graduations shall be in units of MPa and the maximum scale readings shall be not more than 50% higher than the nominal working pressure of the system served.
d) No aluminium shall be used in the construction of the gauges; housing and bezels shall be of stainless steel. The internal components shall be of stainless steel, bronze or some other corrosion resistant material other than aluminium.
e) The gauges shall be mounted directly on a sub-plate or mounted flush on a panel.
f) Each pressure gauge shall be fitted with an isolation valve.
g) Pressure gauges shall be provided to measure the following:
    - Pump delivery pressure;
    - Cylinder feed pressure; and
    - Cylinder return pressure.
h) The normal operating pressure shall be indicated with a red line on the gauges.

29.10.15 Hydraulic Cylinders

a) The hydraulic cylinders shall be of the single or double acting type as appropriate.
b) Horizontally mounted cylinders shall be of length sufficiently in excess of the maximum operating stroke so as to offer sufficient lateral rigidity to the piston when it is at normal full extension.
c) The rods shall be manufactured from stainless steel and hard chromed.
d) The Ra (Relative amplitude) on the rod and cylinder inner surface shall not exceed 0.2 µm.
e) Phosphor bronze guide bearings shall be used.
f) Rod sealing set shall be of the double acting lip seal type, capable of operating in submerged conditions to 10 metres.
g) A wiper seal shall be fitted to the cylinder cover.
h) The piston rod and piston shall comprise the following:
    - A double acting piston manufactured from phosphor bronze or cast iron;
    - Guide bearings of phosphor bronze;
    - Pistons fitted with PU piston sealing sets of the double acting lip seal type; and
    - Piston screwed to the rod and locked with a grub screw.
i) The top and bottom covers shall be attached by high tensile bolts or studs and special care shall be taken to ensure correct tensioning.
j) Where cylinders are connected by flexible pressure hose, the bottom connection shall be fitted with an automatic non-return valve of the pilot operated type to ensure against sudden loss of pressure within the cylinder in the event of a burst in the pressure hose.

k) The cylinders shall be provided with a cushioning arrangement at the extended end to the stroke.
l) Pivoted cylinders shall be provided with trunnions or clevises running on self-lubricating bearings.
m) All cylinders shall have bypass lines with isolator valves.
n) All isolator valves shall be equipped with position indication to prevent operation of the system when in the closed position.
o) All cylinders shall have isolating valves on the connecting pipe work and minimess test points on the inlet and outlet lines.
p) The cylinders shall be provided with pipe rupture protection.

29.10.16 Operating Pressures

In order to minimise leakages and wear on seals, etc., the operating pressures in hydraulic cylinders shall be limited to the following:

- Maximum working pressure: 18 MPa
- Test pressure: 25 MPa

29.11 CORROSION PROTECTION

29.11.1 General

The corrosion protection of all hydro-mechanical Plant shall be in accordance with Section 37 – Painting and Corrosion Protection and Section 28 – Mechanical General.

All components as per definition exposed to “Wet” conditions shall be considered as being exposed to anaerobic and aggressive water conditions.

Gate structure	:	Coating System 073 or 074
Stop Logs	:	Coating System 061
Gate (Slide)	:	Coating Systems 070 and 071 or 072
Sealing Frames/Guides (wet)	:	Coating Systems 070 and 071 or 072
Guides/Yoke (dry)	:	Coating System 070
Operating Tandem and Spindles	:	Coating System 070
Fasteners	:	Coating System 070
Operator Housing	:	Coating System 050 or 051 for lining and 052 or 053 for Coating.

On completion of corrosion protection but before the items are dispatched to Site, the Contractor shall make provision for a final inspection. This shall include all necessary dry film thickness and pinhole tests. The Contractor shall further ensure that all quality control records are up to date and provided to the Engineer. In addition, the elements shall be shop assembled to check the functionality of the components.

29.11.2 Propriety Items

Off-the-shelve components that are supplied as standard corrosion protected items e.g. gearboxes, actuators etc. will be accepted provided that they meet with the corrosion protection requirements of Section 37 – Painting and Corrosion Protection. In these instances, if the specifications cannot be adhered to, the Contractor shall submit full details of the equivalent coating systems for review by the Engineer.

29.12 INSPECTION AND QUALITY CONTROL

Inspection and quality control shall be in accordance with Sections 28 and 38 for Mechanical General and Electrical General respectively.

All Plant items shall be assembled and tested for straightness, tolerance and functionality. The Tests and inspections shall be performed before the items are sent for corrosion protection.

29.13 OPERATION AND MAINTENANCE MANUALS

Submission of Operation and Maintenance Manuals shall be as required under Section 48 – Tests on Completion.

29.14 FACTORY ACCEPTANCE TEST AND PRE-COMMISSIONING

The Tests on Completion of mechanical Plant is generally covered by Section 48. This Section deals exclusively with the Factory Acceptance Testing (FAT) and Pre-commissioning on Site of the Hydro-Mechanical Plant.

29.14.1 General

All Hydro-Mechanical Plant shall be carefully inspected and functionally tested at the factory and pre-commissioned on Site after installation.

29.14.2 Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) shall be carried out at the factory in the presence of and to the satisfaction of the Engineer to demonstrate that the Plant has passed its functional test and fully complies with the specifications.

29.14.3 Pre-commissioning

Pre-commissioning shall be carried out by the Contractor after installation of the Plant on Site in the presence of and to the satisfaction of the Engineer to demonstrate that each part together with all its components functions correctly as a unit.

The Engineer shall have been provided with the most recent draft of:

- The appropriate Operation and Maintenance Manual;

- The complete Data Pack that includes signed-off Quality Control Plans (QCP's), material and test certificates, delivery notes etc; and
- The dry testing procedure, which shall show appropriate detail.

Dry testing of the Plant (in liaison with the Engineer, Contractor and appropriate other Subcontractors where interfaces exist) shall include, but not necessarily be limited to tests that demonstrate that:

- The seals are operating, mechanically, satisfactorily and according to the pre-compression recommended by the gate designer, that the clearances in the guides are adequate, and that the gates work correctly under all specified conditions that can be simulated in the absence of water head;
- The gates are clean and free of construction debris and spindles (stems) threads lubricated prior to operation of the gate; and
- The gates' hoist mechanisms are able to cycle the gate with ease on minimum of 1-1/2 cycles (open-close-open or vice versa) to ensure smooth operation and proof that the gates open fully as per design requirements.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

PART C3.2
TCTA MODULAR STANDARDS

SECTION 30

PUMPS AND ANCILLARY PLANT

TCTA MODULAR STANDARDS

SECTION 30
PUMPS AND ANCILLARY PLANT

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SECTION 30
PUMPS AND ANCILLARY PLANT

30.1 SCOPE

30.5.1.2(d)This Section deals with the design, manufacture, delivery, installation, testing, commissioning, trial operation and activities during the Defects Notification Period of the pumping and ancillary Plant.

The Contractor shall also carry out all civil engineering work, including forming and preparing box-outs, chases etc. to receive the built-in parts, establish concrete around them, and grouting-in base plates, holding down bolts and the like.

This Section shall be read in conjunction with Section 1 – General, Section 28 – Mechanical General, Section 32 – Pipes and Pipe Specials, Section 37 – Painting and Corrosion Protection, Section 38 – Electrical General, Section 39 – Electrical - Plant and Installation and Section 48 – Tests on Completion to Contract End.

30.2 DEFINITIONS, ABBREVIATIONS AND REFERENES

30.2.1 Definitions

For the purpose of this Section the following definitions shall apply:

a) **"Preliminary Acceptance Test"** as defined in Section 48 – Tests on Completion.
b) **"Final Acceptance Test"** as defined in Section 48 – Tests on Completion.
c) **"RL"** means reduced level in metres above mean sea level.
d) **"Flow rate"** means the volume of liquid passing through the pump per unit of time.
e) **"Nominal diameter (DN)"** means a numerical, nominal designation of size that is common to all components in the piping system other than components designated by outside diameters. It is a convenient round number for reference purposes and is only loosely related to the manufacturing dimensions. Nominal size is designated by DN followed by the size in millimetres. All Plant of the same size (DN) designated by the same PN number shall have compatible mating dimensions.
f) **"Nominal pressure (PN)"** means a numerical designation of a pressure rating which is a convenient round number for reference purposes. The maximum allowable working pressure depends upon the materials design and working temperature and shall be selected from the pressure/temperature rating table in the appropriate standards. It is the internal pressure corresponding to the maximum allowable working pressure.
g) **"Static head"** means the difference between the free water surface levels on the suction and delivery sides of the pump.
h) **"External friction head"** means the head required to overcome the friction external to the limits of pump supply.

i) **"Plant losses"** means the friction losses in all pipework, specials and valves within the limits of pump supply.

j) **"Velocity head"** means the head given by ($v^2/2g$) at the point of pressure measurement.

k) **"NPSH Available ($NPSH_A$)"** defines the total absolute pressure above the vapour pressure at the suction nozzle for a given liquid at a certain flow rate and is independent of the pump itself.

l) **"NPSH Required ($NPSH_R$)"** is a pressure characteristic of the particular pump and is given by the pump manufacturer. The head in metres of water required above the reference plane, according to BS 5316 (impeller centre line for horizontally mounted centrifugal pumps) to ensure that cavitation does not occur.

m) **"Duty point"** means that point on the pump H-Q (head-flow) characteristic curve for the required performance of the pump as stated in terms of head in metres and required flow rate in m^3/s or ℓ/s. In some cases, more than one Duty Point may be specified to accommodate system characteristics.

n) **"Minimum transfer"** The minimum transfer rate at which a single pumpset can be operated on a stable and continuous (non-batch) basis.

o) **"Motor power input"** means the power absorbed by the motor that is driving the pump.

p) **"Coupling"** means any process of jointing (except welding) the pump shaft to the motor shaft.

q) **"Special"** means all sizes and shapes of pipe work such as closure pieces, bends, tees, crosses, angle branches, reducers, and tapers.

r) **"Pumpset"** means one pump unit together with its associated motor, coupling, base plate and auxiliaries to deliver the specified quantity at the specified head, and all ancillary Plant.

s) **"BEP"** means best efficiency point which is the point on the pump characteristic curve at which the efficiency of the pump is the highest.

30.2.2 Abbreviations and Material Symbols

For the purpose of this Section, the following shall have the meaning given:

AC	:	Alternating current
CI	:	Cast Iron
DC	:	Direct current
DN	:	Nominal diameter
DS	:	Downstream
H-Q	:	Head – flow relationship
IP	:	A symbol which, followed by two characteristic numerals, signifies the degree of mechanical protection to ingress of foreign bodies and water as defined in SANS 60529.
$NPSH_A$	:	Net Positive Suction Head Available
$NPSH_R$	:	Net Positive Suction Head Required (at 0% head drop)
P&ID	:	Process and Instrumentation Diagram

PN : Nominal pressure
Q : Flow rate
RL : Reduced Level
rms : root mean square
US : Upstream
VSD : Variable Speed Drive

30.2.3 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with OHS Act 85 of 1993, Construction Regulation 2014, Construction Regulation 25 Use of flammable liquids, General machinery Regulation 2 to 9 Safe guarding and operating requirements for machinery.

30.3 STANDARDS

The following Standards and Codes of Practice are referred to in this Section:

American National Standards Institute

ANSI B4.1 : Preferred limits and fits for cylindrical parts

American Petroleum Institute

API 5L : Specification for line pipe
API 1104 : Standard for welding pipelines and related facilities

American Society for Testing of Materials

ASTM A 312 : Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes

American Society of Mechanical Engineers

ASME Section VIII : Boiler and Pressure Vessel Code, Division 1 for Unfired Pressure Vessels

British Standards Institution

BS EN ISO 80000-1:2013 : Quantities and units. General
BS 4360: 1990 : Specification for weldable structural steels

BS 2633: 1987	:	Welding of specials rated to 2,5 MPa and higher (Class I)
BS 2971: 1991	:	Welding of specials rated to less than 2,5 MPA (Class II)
BS 3601: 1987	:	Steel tubing rated higher than 1,72 MPa
BS 916: 1953	:	Black bolts, screws and nuts
BS 970: 1996	:	Wrought steels in the form of blooms, billets, bars and forgings
BS EN 1561: 2011	:	Specification for grey iron castings
BS EN 1563: 2011	:	Specification for spheroidal graphite or nodular graphite cast iron
BS EN 10293: 2015	:	Specification for steel castings for general engineering purposes
BS EN 13835: 2012	:	Austenitic cast iron
BS 4080: 1966	:	Methods for non-destructive testing of steel castings
BS EN 1092-1:2018	:	Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS EN ISO 5198: 1999	:	Specification for acceptance tests for centrifugal, mixed flow and axial pumps

South African Bureau of Standards

SANS 1109-1:2005	:	ISO pipe threads for pipes and fittings where pressure-tight joints are made on the threads
SANS 1091:2012	:	National Colour Standard
SANS 1123:2000	:	Pipe Flanges
SANS 1700	:	ISO metric precision hexagon-head bolts, screws and nuts (coarse thread medium fit series)
SANS 121	:	Hot-dip galvanised coatings on fabricated iron and steel articles

International Standards Organisation

ISO 9001	:	Quality assurance
ISO 9002	:	Quality systems. Model for quality assurance in production, installation and service

30.4 GENERAL REQUIREMENTS

30.4.1 Scope of Design Work

The Contractor shall be responsible for the integrated design of a pumping system and the required ancillary components that integrates with the bulk water transfer scheme.

The scope of the design shall include but not necessary be limited to:

a) The final pump selection;
b) The integration of the pump, motor, VSD and starter configuration;
c) The integration of the relevant power supply;
d) The integration of the pump control and the rising main surge conditions;
e) The integration of the pump control and the suction pipeline surge conditions;

f) Shaft couplings;
g) Ancillary Plant: seal water flow control valves and protection Plant items;
h) Valves;
i) Actuator systems for all valves in the pumping station(s);
j) Integration of instrumentation with reference to Section 40 - Control and Instrumentation General as required to render the Plant safe in operation;
k) Cranes, confirming span, long travel and cross travel with reference to Section 31 – Cranes, hoists and winches; and Construction regulation 22 Cranes, Driven machinery regulation 18 Lifting equipment and devices.
l) The design shall take into account the given control philosophy as set out in Section 40 – Control and Instrumentation General.

30.4.2 Submission of Design Information

At least the following detail design information shall be included in the design documentation to be submitted for review by the Engineer prior to ordering the Plant:

a) General arrangement drawings defining the Plant arrangement. Unless clearly stated and indicated otherwise on a drawing, critical dimensions proposed in this Section will be considered as agreed upon by the Contractor;
b) Piping and Instrumentation Diagrams (P&ID) with details of all Plant indicated on the P&ID;
c) Pumpset layouts: To scale, dimensioned drawing, giving overall dimensions of the pump set and the required base plates and concrete plinths with typical pump construction details defining pump seals, shaft sleeves, sealing rings, bearings etc.;
d) Pump general cross-sections: To scale, dimensioned drawings showing materials of construction including general dimensions of the pump impellers;
e) Characteristic performance curves for pumps, including as a function of discharge head, pump efficiency, overall efficiency, pumpset power required, NPSH required for 0% and 3% head drop, NPSH available;
f) Pump performance curves superimposed on pipeline system curve to demonstrate compliance with Minimum, Nominal and Design Transfer Rate Duty Points.
g) Typical motor details: drawings showing for each type of motor offered, general motor arrangement, details of bearings, windings, terminal box, cable entry box, ventilation, insulation system, method used to lock the rotor bars in the slots, thermal characteristics of temperature sensors, air filtering, water cooling etc.;
h) VSD details (where applicable): drawings showing layout, ventilation arrangement, cable routes etc.;
i) Characteristic curves of motors;
j) Motor/pump - speed/torque curves expressed in absolute terms - not only percentage of full load;
k) Detailed designs (including stress and hydraulic calculations where appropriate) of all the connecting pipework between the valves and pumps etc. including drawings indicating positions and details of where flange adapters will be installed, positions of scours, positions

of off-takes for bypasses, tapping points for thermodynamic monitoring connections, pressure gauges and pressure transducers etc;

l) Fully dimensioned drawings showing pump plinths, foundation and holding down and other fixing bolt sizes and positions and sizes of openings to accommodate the Plant; and

m) Diagrams indicating the interconnection of the electrical operation of all the Plant to be installed by the Contractor.

30.4.3 Operating Temperature

Each pump and electric motor shall be capable of operating satisfactorily at maximum shade temperature of 45°C. The temperature of the pumped liquid will not exceed 25°C.

30.4.4 Vibration Standards

A machine will not be acceptable if vibration is outside the limits prescribed in Clause 30.10.4. Maximum vibration amplitudes are specified on bearing housings measured in the horizontal, vertical and axial planes. Machined surfaces (50 mm x 50 mm) shall be provided for these measurements on the housings.

Pumpsets shall be accurately balanced statically, dynamically and hydraulically in accordance with SANS 948, Table 25 or an internationally recognised Standard.

30.4.5 Noise Limits

Plant or a combination of Plant shall not exceed the maximum noise limit of 75 dBA. (Refer to BS 4999: Part 51 Test Method II). Compliance to Noise-induced hearing loss regulation 1 to 13.

30.4.6 Interchange Ability

All pumps, motors, valves, spares, etc., of the same size for the specified duty shall be interchangeable without the necessity of additional machining or fitting.

30.4.7 Dismantling Ability

The design and arrangement of the pump casing shall ensure that it is not necessary to disconnect the delivery pipework or interfere with the alignment of the pumpset, when removing or replacing the complete rotating element.

30.4.8 Insulating Flanges

Insulating flanges (IF) complete with spark-gap arrestors shall be supplied and installed at the flanges of the manifold branches. The testing of the insulating joints shall be witnessed by the Engineer. The proposed test method and sequence shall be agreed with the Engineer in order to ensure the efficiency and compliance regarding electrical isolation. Refer to Section 28 – Mechanical General and Section 34 – AC Mitigation and Cathodic Protection.

30.4.9 Connecting Pipework

All pipework and flanges upstream and downstream of pumps shall have a minimum rating of 1000 kPa or higher as required by internal pressures. When working with pipes under pressure, compliance with Pressure Equipment Regulation 2, 3, 4, 7, 9 and 10 to be adhered too.

All reducers directly upstream and downstream of the pumps shall be of concentric design.

Attention shall be given to the corrosion protection requirements for raised face flanges. Corrosion protection for the exposed area shall be similar in all respects to that applied externally to the pipework/valve/pump.

Provision shall be made for minimum DN100 scour branches, ½" BSP stainless steel tapping points upstream and downstream of each of the pumps for pressure transducers, pressure gauges and 1" BSP stainless steel tapping points upstream and downstream of each of the pumps for thermodynamic efficiency testing points fitted with ¼ turn stainless steel ball valves for isolation and a 1” BSP steel tapping point upstream for a flow switch.

30.4.10 Dimensions and Assembly

All parts shall be robust and of the most suitable material, corrosion-resistant, free from flaws, accurately machined, properly assembled and fitted so as to avoid initial stresses and to ensure free running of all rotating parts. All fittings such as packing glands, shaft assemblies, thrust bearings and plummer blocks shall be of adequate size and sound design.

30.5 DESIGN, MATERIALS AND MANUFACTURING

30.5.1 Pumps

Pumps and ancillary Plant shall be capable of withstanding the specified test pressures set out below.

The design, materials and protection system shall comply with the relevant requirements set out below.

Spilt Casing pumps shall be able to operate in the vertical or horizontal position. Pumps shall be coupled by metal flexible couplings to standard motors.

All horizontal mounted pumps with two or more stages and all horizontal single or double suction pumps shall have the impellers mounted between bearings.

30.5.1.1 Permissible Design Stresses

In the design calculations, the Contractor shall make provision for the worst possible conditions that may have to be encountered by the Plant, whether during operation or during fabrication, transport or installation.

The following permissible stresses shall apply, unless lower % of the elastic limits are specified by the designer:

a) “Normal permissible stress” in steel: 50% elastic limit; and
b) “Exceptional permissible stress” in steel: 75% elastic limit.

In the case of a component subjected to stress in several directions, the equivalent permissible stress shall be equal to the “exceptional permissible stress”.

For pump casings the design stress used for any material shall not be in excess of the values given in ASME Section VIII, Division 1 for “Unfired Pressure Vessels” for that material. For cast materials, the factor specified in the ASME Boiler and Pressure Vessel Code shall be applied. Pressure casings of forged steel, rolled and welded plate, or seamless pipe with welded cover shall comply with the applicable standards of ASME Section VIII, Division 1.

30.5.1.2 Pump Selection

(a) Impeller Size

No pump, with a constant speed driver, which requires a maximum or minimum diameter impeller to meet the rated pumping conditions, will be accepted.

The impeller diameter shall be such that at least a 5% increase in head at the Duty Point(s) can be obtained by installing a larger diameter impeller of the same pump pattern. The impellor size selected shall be as close as possible to the BEP of the pump pattern.

(b) Operating Characteristics

The pumps shall be capable of operating over the full operating head range between all defined Duty Points, without motor overload or perceptible signs of cavitation.

Pump impellers shall have the characteristic of generally decreasing head with increasing capacity from shut-off to maximum capacity.

Throttling of the discharge valve will not be permitted to meet reduce transfer capacity

(c) $NPSH_R$

$NPSH_R$ curves for both 0% and 3% headloss shall be included with the pump characteristic curves.

(d) Efficiency

The efficiency curve shall be flat over a wide range in order to provide efficient operation with various pump operating conditions. The BEP should be to the right of the duty points.

(e) Operating Speed

The pump shaft rotational speed shall not exceed 1500 rpm (4 pole speed).

30.5.1.3 Specific Speed

Specific Speed, N_S, (defined hereunder) shall have a value of between 10 and 30 per impeller, unless detailed and acceptable justification is given:

$$N_S = \frac{n.\sqrt{Q}}{H^{0.75}}$$

Where:

n	=	rotational speed in revolutions per minute.
Q	=	capacity in m^3/s (if single suction, equals capacity of the pump).
H	=	dynamic head in metres at any speed.

30.5.1.4 Suction Specific Speed

Suction Specific Speed, S, (defined hereunder) shall under no circumstances exceed the value of 160 per impeller inlet, unless detailed and acceptable justification is given:

$$S = \frac{n.\sqrt{Q}}{NPSH_R^{0.75}}$$

Where:

n	=	rotational speed in revolutions per minute.
Q	=	capacity in m^3/s (if single suction, equals capacity of the pump).
$NPSH_R$	=	Net positive suction head required.
H_a	=	atmospheric pressure at the elevation of the pump in metres of water.
H_s	=	difference in level of the highest point of the impeller entry above the water level on suction side, increased by the head losses in the suction line in metres of water.
H_v	=	Velocity head ($v^2/2g$).
H_{vp}	=	vapour pressure in metres of water.

30.5.1.5 Materials Requirements

(a) General

All materials shall be suitable for pumping the quality of water from the designated source. Properties claimed for these materials shall, unless specified otherwise in this Section, comply with the requirements of the most recent edition of the appropriate South African or other internationally recognized standard specification.

For each type of Plant, the manufacturer shall specify the materials for each of the proposed sub-assemblies.

The Plant shall be manufactured using new prime quality materials taking into account the latest technical innovations.

All components shall have a surface finish in relation to their importance, their position and their intended purpose.

Rolled steels and all castings shall be clean and free of blisters, porosity, shrinkage, holes, cracks or other flaws which may be detrimental to their use.

(b) Compatibility of Materials

The responsibility for selecting materials which are compatible with (able to prevent corrosion and/or abrasion) the liquids or surroundings with which they come into contact rests with the Contractor. The materials used shall be at least equal to those specified in this Section and shall be subject to the review of the Engineer, if different from this Section. The responsibility for selecting suitable materials of construction rests with the Contractor.

(c) Castings

Castings shall be sound, free from shrink or blow holes, scale blisters and other similar defects. The surfaces shall be cleaned by the supplier's standard methods. All casting burrs shall be filed or ground flush with the surface of the casting.

Porous castings shall be rejected. The repair of leaks and defects in pressure castings shall only be allowed after the review of the Engineer had been obtained. It shall then be executed strictly in accordance with rules of Section VIII of the ASME Code.

The filling of casting defects shall be carried out by highly qualified welders only, according to latest welding techniques.

Any cast component requiring filling at any fabrication stage after the first anneal shall be subjected to further annealing treatment. Cast components shall not be warped or distorted in any way and shall not show any increase in dimensions after casting (beyond that shown on the fabrication drawings) likely to cause interference with other components in the erection of the item of Plant for which they were made. The structure of cast components shall be homogeneous and free of slag intrusions. If, at critical points of a cast component, there is too great a concentration of impurities or alloy, the component shall be rejected. Casting materials shall be homogenous and stress relieved.

(d) Stainless Steels

Stainless steel shall be of the type easily jointed or filled by electric welding. Stainless steel which cannot withstand the effects of welding or associated heat treatment will not be accepted.

30.5.1.6 Pump Casing

(a) General

The pump casing shall be manufactured in normal SG Iron to grade GGG.

All pressure casings shall be of such thickness as will be suitable for the maximum discharge pressure (plus surge pressure) at pumping temperature and hydrostatic test pressure at ambient temperature, with a 3.2 mm minimum corrosion allowance. Casings shall have stiffening ribs at all points of high stress. Particular care shall be exercised in designing a pump casing to resist the tendency to crack through the cutwater or guide passage walls during pressure tests.

Pumps shall be furnished with suction and discharge flanges integrally cast with the casing. Where the pump supplier's standard pattern offers a flange thickness and diameter greater than that specified, the heavier flange may be furnished, but it shall be drilled as specified. All cast iron castings with flanges or other bolted mating surfaces shall have a full width gasket surface.

Pumps shall be provided with a vent connection unless the pump is made self-venting. All horizontal drive pumps shall be provided with a drain connection.

The backs of all flanges shall be machined full-face or spot-face and bolt holes shall straddle the horizontal and vertical centrelines.

Provision shall be made on each pump for removing the pump casing cover and the shaft assembly without disturbing the motor drive or having to disconnect any pipework apart from small bore pipes such as vent pipework and the like. Lifting facilities for the casing cover and shaft assembly shall be provided where these cannot be reached by overhead crane.

All vent, lantern ring, case drain, or seal recirculation connections on pumps shall be threaded according to SANS 1109.

Each pump shall be provided with a cast-in or permanently attached metal plate with direction-of-rotation arrow.

(b) Internal Protection

The inside of the pump casing shall be lined with Vinyl Ester Glass Flake Epoxy or Ceramic Epoxy lining (or equal) to give a smooth, high-quality surface which will protect the steel against abrasion and corrosion and also improve the pump efficiency over the life time of the pump.

(c) Casing Eye Rings

Renewable phosphor-bronze (PB1) (or equivalent material) eye rings shall be provided on all pumps.

30.5.1.7 Impellers, Wear Plates and Wear Rings

Multi-channel, shrouded impellers with optimum vane geometry to provide high efficiency, low $NPSH_R$ and minimised pulsations in the discharge are required.

The arrangement of the impellers shall be such as to reduce the residual axial thrust to a minimum. Designs incorporating a balanced, double suction arrangement are required.

Impellers shall be made of stainless steel of a suitable grade from new ingot material. Materials highly resistant (such as high chrome iron) to abrasion resulting from grit contained in the pumped liquid, shall be used in making the wear plates, wear rings and liners (as applicable).

All water passages shall be polished to a smooth finish; water passages which cannot be machined shall be hand ground and filed to a template.

Entrance to the vanes at the eye of the impeller shall be smooth and leading edges of the vanes shall be ground to the optimum profile consistent with best efficiency and cavitation-free operation.

Lines showing the designed width of the water passage at the outlet shall be scribed on the impeller periphery when the impeller is being machined. The internal surfaces of the impeller shall be finished off to these machined lines smoothly and symmetrically; bevelling the metal to conform to the scribed lines will not be accepted.

Impeller shrouds shall be of adequate thickness after they have been machined, the thickness depending on the impeller diameter. Impellers for similar pumps shall have the same outside diameter and shall be interchangeable.

Where impeller eyerings are not fitted, the design of the impeller eye shall be such that sufficient thickness is left so that material can be machined away at a later stage and either impeller eyerings, or undersize casing eyerings fitted. Replaceable wearing rings shall be made of the same material

as the impeller. Unless otherwise approved by the Engineer these rings, which shall be "L" cross-section, shall be secured to the impeller with non-corroding screws and mechanically locked.

Each impeller shall, after final machining and dressing be independently statically balanced, and the completely assembled rotating element, with coupling shall be dynamically balanced, the latter at not less than half the maximum rated speed for which the specific pump has been designed.

Drilling holes in the impeller to balance it with regard to mass distribution is not acceptable. After completion of the balancing procedure, results of the test in the form of a certificate shall formally be submitted to the Engineer.

The first critical speed of the rotating element shall be at least 15% higher than the maximum running speed.

For raw water, the impeller shall be suitable to allow passage of debris and silt.

30.5.1.8 Diffusers

Where fitted, diffusers shall be cast in zinc-free bronze or stainless steel and shall be provided with a smooth finish through the hydraulic passages.

30.5.1.9 Shafts

Pump shafts shall be suitably heat treated and of sufficient dimensions to transmit the power to which they will be subjected without undue torsional or bending stresses and deflection. Shafts shall be designed of such material as to be resistant to pitting corrosion and fatigue failure, i.e. EN57 or equivalent.

The shafts shall be stress-relieved after initial machining, and ground to final size. The shafts shall be suitably designed for the reception of the impeller which shall be adequately secured to the shaft in such a manner as to be readily removable without damage to either the shaft or the impeller.

The Contractor shall ensure that both the critical speed and torsional oscillation characteristics of the combined pump and motor rotating elements are satisfactory for all possible conditions of operation.

Provision shall be made on each pump shaft or coupling for checking speed by means of a hand tachometer of the reflective digital read-out type.

30.5.1.10 Shaft Sleeves

The shafts shall be fully protected with replaceable sleeves of bronze, stainless steel or other equivalent non-corrodible material at all areas where wear and/or corrosion could possibly be expected. These sleeves shall be readily removable without causing damage to either the shaft or

the sleeve. Sleeves shall be ground with a polished finish on the wearing surface. They shall be fitted to all pumps where the shaft passes through the stuffing box. The sleeve shall extend a minimum of 3 mm beyond the gland plate.

30.5.1.11 Bearings and Lubrication

(a) Bearings

The bearings in the pump casing together with the lubricating system shall be suitable for the particular circumstances described in the Section. Where pumps are required to operate in any plane (horizontal, inclined or vertical) the bearings shall be specially designed for the specific operating conditions. The Contractor shall submit to the Engineer full details of the type of bearings and lubrication system offered.

Split type journal bearings with oil lubrication shall have preference. The journal bearings of large, slow revving and multi-stage horizontal pumps shall generally be white-metal lined bronze sleeves, split on the horizontal centre line, and/or “Glacier” type bearings as specified by the pump manufacturer.

Ball and/or roller bearings in pumps shall be of the sealed or re-greasable lubricated type. Ball or roller bearings shall be loaded conservatively in order that the grease may be renewed at intervals of not less than one year and they shall not be equipped with grease nipples or cups. If these are supplied, they shall be replaced with threaded plugs. For purposes of maintenance, end shielded bearings are required. A minimum bearing life of 40 000 hours is required.

The pump shaft shall be located in the axial direction. Where necessary a thrust bearing shall be provided to accommodate the end thrust of the impeller(s), and the mass of the rotating element. Thrust bearings for vertical pumps may be located in the drivers.

All bearings shall be equipped with pockets for RTD's for temperature monitoring.

All bearings shall be suitable for shaft rotation in both directions.

To facilitate replacement, the bearing numbers for all bearings shall be given together with other data to be provided by the Contractor.

(b) Cooling

All bearings shall be designed to run continuously in ambient temperatures.

The cooling of the bearing shall be natural or by forced air circulation.

If water cooling is necessary, stainless steel oil/water coolers shall be incorporated in the bearing oil reservoirs. The system shall make use of water of the same quality as the water being pumped. All

cooling water pipework, valves and fittings shall be of compatible material. The water side of the cooler tube assembly shall be hydraulically tested after installation has been completed, to 3 times the maximum working pressure. Test pressures shall be maintained for 30 minutes and the tests witnessed by the Engineer.

If cooling water is required for the bearings, the supply shall be provided by a cooling water pump which serves the motor cooling system and a water flow relay shall be fitted in each heat exchanger circuit (also refer to Clause 30.5.3.1).

The cooling water shall be conditioned on Site to prevent fouling of pipework, heat exchangers, cooling water pumps or seals.

(c) Lubrication

Bearings shall be either oil-bath or grease-lubricated.

30.5.1.12 Mechanical Seals

Large pumps (larger than 50 kW) shall be fitted with mechanical seals, unless otherwise approved by the Engineer.

The mechanical seals shall be capable of resisting, without leakage, both the suction and discharge pressure as specified. The seals shall require neither maintenance nor adjustment and shall operate without water being pumped.

Seals requiring an independent source of cooling water are not favoured. If cooling water is required for the mechanical seal, full details shall have been submitted by the Contractor at Tender stage. If the quality of the water necessitates filtration, the Contractor shall provide the appropriate Plant. Filters shall (as a minimum), be of the “twin-barrel” (quick change-over) type and must default automatically to “bypass” in the event of blockage. The flow of water to or from the seals shall be clearly visible. For cooling water flow the control unit (flow and pressure) shall be adequately sized to allow sufficient flow rate through the seals as recommended by the seal manufacturer.

The design of the seal shall be such that the static head on the pump discharge induces a closing action on the seal to ensure that no leakage occurs during pump shut-down.

(a) Mechanical Seal and Flush Water

A single self-aligning balanced mechanical seal manufactured in grade 316 stainless steel and fitted with at least matched solid tungsten carbide (or other approved by the Engineer) rotating and stationary faces shall be supplied.

An external flush shall be provided to ensure heat dissipation through circulation. Where raw water is being pumped, a cyclone separator or other suitable device shall be fitted to condition the water required by the mechanical seal.

(b) Raw Water and Abrasive Liquids

A double self-aligning mechanical seal manufactured in grade 316 stainless steel and fitted with at least either carbon on ceramic (for water lubrication) or carbon on solid tungsten carbide (for oil lubrication) shall be fitted on the end of the seal not in contact with the liquid being pumped. At least solid tungsten carbide on solid tungsten carbide shall be fitted on the end in contact with the pumped liquid. Should the Contractor's designer consider it to be necessary, seals of greater technical sophistication (than tungsten carbide) shall be fitted.

If required, an independent fresh water (or oil) flushing system shall be provided. Care shall be taken to ensure that the pressure of the cooling fluid is at least 100 kPa greater than the pressure of the liquid on the inboard side of the seal. Built-in or integral type seals are unacceptable.

30.5.1.13 Flanges and Accessories

All pumps and ancillaries shall be supplied complete with couplings and jointing material. Each flange and fitting shall be supplied complete with one insertion piece of the appropriate diameter and made of compressed non-asbestos or other suitable material for medium to large diameter flanges and medium to high (4.0 MPa and over) pressure pipelines, and one set of bolts, nuts and washers.

The drilling patterns and thicknesses of steel and CI flanges shall conform to the requirements of BS EN 1092 Part 1 and BS EN 1092 Part 2 respectively. The minimum pressure rating of flanges shall be 1000 kPa.

Sealing faces shall be machined flat to a toolmark of 0.8 mm to 1.25 mm pitch spiral or concentric serrations, and backs of flanges shall be either machined or spot-faced around holes with sufficient clearance to ensure proper seating of bolt heads and nuts.

The Contractor shall ensure the compatibility of the drilling pattern of all flanges that are to be connected together. The Contractor shall ensure that the flanges in a subcontractor's supply will match the flanges supplied by others or at interfaces between subcontracts, if any.

30.5.1.14 Fasteners

All high tensile bolts and studs used shall bear the letters HTS stamped or engraved on the end. Washers shall be provided under all bolt heads and nuts. The threads of bolts and studs shall be cleaned and coated with a Molybdenum Disulphide or Nickel Anti-seize compound before assembly. The threads of all bolts and studs used with the Plant supplied shall be to the same standard. All black steel fasteners shall be Hot Dip Galvanised in accordance with SANS 121.

30.5.1.15 Couplings

The pumps and motors shall be direct coupled with a type of flexible coupling which will take up minor misalignment or off-setting of the motor and pump shaft satisfactorily. Flexible tyre-type couplings are acceptable for pumps coupled to motors up to 100 kW. Where motors are rated above 100 kW, all metal (curved tooth or equivalent) couplings shall be used in all horizontal drive units. Where applicable, provision for adequate lubrication shall be made.

The coupling shall be designed in such a manner that no axial or radial loads will be imposed on the motor and pump bearings in excess of the loads approved by the motor and pump manufacturers respectively for the installation offered. Spacer couplings shall be provided with pumps of the back pull out type, where mechanical seals are fitted or where frequent maintenance is likely to be required.

Couplings shall be mounted on shafts with cylindrical fit conforming to ANSI B4.1 and keyed in place. The couplings shall be robust, shall be readily dismantled and reassembled, and shall have a service factor of at least 1.5.

30.5.1.16 Safety Instrumentation

All pumpsets rated 110 kW and over, shall be fitted with vibration detectors on the bearings and automatically shut off the motor in the event the amplitude exceeds the manufacturer's recommended limit.

The main bearings shall be fitted with the necessary safety instrumentation and trips as follows:

(a) Temperature

Resistance Temperature Detectors shall be provided for motor stator windings and comply with Section 39 - Electrical - Plant and Installation and the bearings for both motors and pumps shall be as specified in Section 41 – Control and Instrumentation Plant and Installation.

All motors shall have embedded in their stator windings, two RTD's per phase, which shall automatically shut off the motor in the event of overheating of the stator windings.

All pumpsets rated 55 kW and over shall be fitted with RTD, thermal sensors in the drive-end and non-drive-end bearings to give a warning and automatically shut off the motor in the event the bearing temperature exceeds 80°C, or as recommended by the manufacturer.

(b) Vibration Sensors

Suitable vibration sensors shall be mounted on each pumpset to stop it on detection of excessive vibration. At least two detectors shall be provided on each pumpset, i.e. one on the motor and one

on the pump, situated as close as possible to those bearings where the highest vibration levels are encountered. The indicating instruments shall be suitably calibrated. They shall be of a type such that it is possible to set different tripping levels corresponding to different RMS velocities.

The monitoring of vibration shall be made via a suitable timing device in order to avoid tripping when starting the pumpset or during other transitory conditions.

30.5.2 Motors

Motors for pumps shall form part of the Contractor's design and comply with Section 39 – Electrical - Plant and Installation.

Guaranteed torque/speed characteristics for motors from zero to full speed shall be supplied.

Motor bearings shall comply with Clause 30.5.1.11. All bearings shall be equipped with RTD type temperature sensors and leads from the RTD's shall be wired to a separate terminal box.

Motor winding temperatures shall be continuously monitored by means of RTD's embedded in the windings.

The motors shall be equipped with 240 V anti-condensation heaters to keep the motor windings free of ingress of moisture when motors are switched off. A special terminal box mounted on the motor shall be fitted with a red pilot lamp to indicate when the heaters are on. The heaters shall be wired such that they turn off when motor power is applied.

Motor winding terminal boxes shall accommodate surge arrestors. The surge arrestors shall be included in the offers for the motors.

30.5.3 Ancillary Plant

30.5.3.1 Cooling Water System (CWS) and Flushing Water to Motors and, Bearings and Mechanical Seals

Pump motors shall be air-cooled unless a cooling water system (CWS) is necessary for a specific installation. Should a cooling water systems for the pump motors be necessary, the following requirements will be applicable.

(a) General

Two circulation pumps are required, one running one standby. The complete CWS shall be an open loop system. The pumps shall extract water from the main suction pipeline and pump it through the motor cooling system and bearing cooling system of both pump and motor and back into the main suction pipeline. The Contractor shall be responsible for installing a water conditioning system (if the

Contractor deems it to be necessary), as the water being pumped to the motors, bearings and seals will be unfiltered raw water from the pump source.

(b) Cooling Water Pumps

Two cooling water pumps, one running and one standby, are required for the water cooling circuit. These pumpsets shall be of the close coupled back pull out design in which a standard motor is flange mounted on the pump, the pump impeller and motor shaft being coupled by means of a spigoted flange coupling. One spare pump unit (not connected) complete with motor shall be provided for the cooling water circulation, water conditioning and sealing required in the pumping station.

Monoblock pumps with an extended motor shaft on which the impeller is directly mounted are not acceptable.

The pumps shall be sized to supply adequate flow and pressure for the complete cooling water, water conditioning and sealing requirements of the entire pumpsets inside the pump station.

The cooling pumps shall operate on a four pole motor speed. They shall be fitted with stainless steel shafts, bronze impellers, and mechanical seals. They shall be fitted with removable perforated coupling guards fixed over the openings giving access to the pump/motor coupling. They shall be mounted on neat concrete plinths not less than 150 mm high.

(c) Cooling Water Piping and Fittings

All cooling water piping shall be galvanised steel piping except where pipes are passing through concrete or are buried under concrete in which case they shall be stainless steel 316L. Care must be taken to avoid galvanic cells between different materials. For auxiliary pipes to seals and bearings refer to Clause 30.6.5.

All piping shall be sized to supply adequate flow and pressure for the complete cooling, water conditioning and sealing water requirements of all the pumpsets inside the pumping station.

All valves shall be full way brass or stainless steel bodied ball valves with chromium plated brass or stainless steel balls. The use of gate valves is not permitted.

Reflux valves may be or the wafer or bronze flap type with flange connections.

Unions and pipe sockets shall only be used for 15 to 40 mm piping; all larger sized piping shall be flanged. All unions used shall be “navy” unions with bronze facings.

Unions and flanges shall be so arranged that any one of the pumps together with its motor can be removed with a minimum of disturbance to the rest of the cooling water pipe-work, leaving the isolating valves in place so that the second pump set can continue operating.

All bends shall be medium or long sweep bends; elbows will not be permitted. All bends shall be T-pieces to allow rodding in case of blockages.

All tees in the main circulating pipes and those branching off the main supply and return cooling water pipes to the pumps and motors shall be fabricated sweep tees using medium sweep weld bends for the fabrication thereof.

(d) Cooling Water Conditioning System

Should it be required, the Contractor shall design, supply and install a dedicated water conditioning system that will ensure suitable quality for the CWS. The source of the water conditioning system will be the raw water abstracted from the pump source. The water conditioning system shall be 100% available and provide for suitable redundant units.

30.5.3.2 Motor Cooling Water Flow Control Valves

Each motor cooler shall be equipped with a combined flow control/flow indicator/flow switch device installed in the main discharge pipes of the cooling water pumps. The flow switch shall be set to prevent start up and to trip the complete pump set when there is no cooling water flow or the flow drops below the minimum required flow rate. A bridging timer is required to allow for the pumps to start-up.

30.5.3.3 Seal Water Flow Control Valves

Each seal shall be fitted with a combined, flow regulator/pressure regulator/flow indicator and flow switch. They shall be fitted on the inlet pipe to each seal. The flow switch shall trip the pump in the event of a low flow or no-flow condition. Hydraulic fittings and all rubber hoses shall be factory crimped. No pipe clamps will be allowed.

30.5.3.4 Protection Plant Items

(a) Pressure Gauges

Pressure gauges shall be installed where indicated on the P&ID’s.

Pressure gauges shall be as specified in Clause 30.6.7.

30.5.4 Valves and Actuators

All valves and actuators shall comply fully with the requirements of the Section 35 - Valves.

30.5.4.1 Isolating Valves

Each pump line in the pumping station shall be equipped with isolating valves installed on the suction and delivery side of the pumps suitable for the water quality to be pumped.

The pressure rating of the valves shall be a minimum of 1000 kPa or higher as specified by the designer. Butterfly valves shall be of the replaceable resilient seal arrangement with double offset.

The isolation valve shall be equipped with a suitable electrically driven actuator. The actuator shall feature a local/remote switch and pushbuttons for stop, open and close. No wireless remote control of the actuator is required.

30.5.4.2 Non-return Valves

Non-return valves on the pumplines inside the pumping stations shall comply with the requirements of Clause 35.7 of Section 35 – Valves.

The valves shall have a minimum pressure rating of 1000 kPa, unless a higher rating is required by the internal pressures.

30.5.4.3 Small Bore Valves

All small bore valves shall be stainless steel, two piece body, ¼ turn ball valves and of minimum nominal bore 19 mm. All manually operated valves installed on the cooling water system shall be suitably rated for the pressure under which they operate.

Provision shall be made for drain valves on all suction and delivery pipe specials of both the low-lift and high-lift pumps.

Air release valves are required with isolating valves.

30.6 SUNDRIES

30.6.1 Safety Guards

Removable or hinged galvanised wire, expanded steel mesh or sheet metal cages shall protect all shafting and couplings. Guards shall be sufficiently heavy and rigid in design to avoid accidental body contact with the coupling or shaft. Guards shall be provided in accordance with the Machinery and Occupational Safety Act.

30.6.2 Air and Drain Cocks

Adequately sized air valves to enable the entrapped air to be released freely shall be provided on the pumps and at any high points on the delivery mains within the limits of pump supply.

Drain cocks shall be provided on the pumps, and also on drains from the pump seals.

All water and drain cocks shall discharge visibly into funnel shaped receivers and small bore tubing (permatube or galvanised) discharging to waste.

30.6.3 Baseplates

Pumps and motors shall be mounted on baseplates of rigid design, manufactured in either cast iron or fabricated steel, equipped with anchor bolt holes, anchor bolts and drain connections. Grout holes in concrete bases shall be unobstructed.

CI base plates shall be fully machined to receive the pump or motor. Fabricated steel baseplates shall be substantially ribbed and stress relieved before any machining is undertaken. Baseplates shall be machined at the points of contact with the pump and motor supports so that the set may be mounted on the baseplate in correct alignment without the use of shims. In addition, at least four levelling pads (all machined to the same height relative to the other machined surfaces) shall be provided so that the baseplate can be accurately levelled up on Site. Refer to Section 28 – Mechanical General, regarding shims and alignment. Machining is not required for units of 15 kW and under. Permanent dowelling pins shall be fitted after each item of Plant has been in normal operation for at least 72 hours and after the final alignment has been inspected by the Engineer.

Baseplates and pump supports shall be so constructed and the pump so mounted as to minimise misalignment caused by deflections arising from normal piping strains, internal differential thermal expansion, hydraulic piping thrust and similar causes.

At least two holes of 50 mm diameter shall be cut into baseplates for grouting purposes without having to remove the pump or motor. Levelling bolts with set screws and nuts shall be fitted to the base plates of all units 100 kW and above. Corrosion protection of baseplates shall comply with the requirements of Section 37 – Painting and Corrosion Protection.

30.6.4 Anchor Bolts

Anchor bolts shall not be less than M20 and shall be of high tensile steel bolts/studs.

Unless otherwise specified by the designer, one of the following methods to fix the anchor bolts shall be used:

a) The Contractor shall drill holes of an appropriate diameter and depth into the concrete plinth, and grout the anchor bolts in, using a pre-packed two-part epoxy mortar; or
b) Pockets at least 100 mm square and at least 12 bolt diameters in depth shall be left in the concrete plinths.

The pump supplier shall be responsible for providing the Contractor with an accurately constructed rigid template to fit on top of the plinth formwork and into which the anchor bolts will be bolted. The details of the template shall be such that it does not obstruct the concreting of the plinth.

30.6.5 Auxiliary Pipe Systems

Recirculation piping systems for gland oil, lubrication oil, bearings, seals and accessories such as gauges and valves, shall be furnished by the Contractor such as to facilitate easy maintenance. Material used for all auxiliary piping and valves shall be stainless steel 316 and shall be suitable for the designed duty of the pumps. All items shall be properly cleaned before assembly. Auxiliary piping shall be installed in a manner which prevents damage to the instruments and gauges due to the vibration of the pump.

30.6.6 Auxiliary Piping to Mechanical Seals

18 Cr-8 Ni stainless steel piping or tubing shall be used for the flushing fluids to mechanical seals. Minimum tubing wall thickness for sizes up to 20 mm OD sizes shall be 1.65 mm.

Tubing connections shall be “Crawford Swagelok” or equivalent. Tubing fittings and ferrules shall be 18 Cr-8 Ni Stainless Steel. Copper tubing and brass fittings are unacceptable.

Auxiliary piping connections shall be plugged with solid plugs. Carbon steel plugs shall be used with cast iron casings, otherwise the plugs shall be of the same metals as the casing material. Plugs shall have a shank to facilitate the use of a pipe wrench.

30.6.7 Pressure Gauges

Pressure gauges shall conform to SANS 1062:2010. The pressure gauges shall have 100 mm diameter dials with stainless steel casing, glycerine filled complete with separate stainless steel isolating ball cocks. The gauges shall be capable of displaying the maximum and static pressure but their maximum pressure reading range shall not be higher than 150% of the operating pressure.

Pressure gauges together with stainless steel ball cocks shall be fitted on the suction and delivery sides of all pumps and shall be suitable for the applicable water quality.

The pressure gauges shall be calibrated to a common datum corresponding to the pump centre line level. The datum level and the difference in level between the datum level and the mounting height of the pressure gauges shall be indelibly marked on the dials of the respective pressure gauges.

One suction pressure transducer, and one delivery pressure transducer, per pumpset shall be supplied and installed together with the gauge, suitable for an input range corresponding to that of the respective pressure gauges. The transducers shall have an output of 4 - 20 mA over the scale range specified for the associated gauge. A suitable DC power supply for each pumpset shall be supplied to power the transducer.

After erection, and before completion, each pressure gauge, each pressure transducer and each pressure switch shall be set at the correct set point on Site. Each pressure switch shall be set by the Contractor to operate at the minimum suction pressure of the pump, and the setting shall be marked by means of an engraved label to be mounted at the pressure switch. Calibration certificates shall be submitted to the Engineer for each gauge, transducer and pressure switch after the Site set point has been set.

Pump pressure gauges shall be connected as follows:

a) Pressure tapping sockets /nipples arranged to connect to the suction and delivery branches at a horizontal position on the pipe circumference;
b) Suitable bosses, tapped and faced, shall be provided on the suction and delivery piping of each pumpset to accommodate the pressure gauge and transducer. Pressure gauges shall be fitted in such a manner that vibrations from the pump and/or pipework cannot be transmitted to the pressure gauges;
c) Suitable brackets shall be supplied and installed to support the pressure gauges, transducers and switches. Each gauge and transducer shall be provided with an isolating cock and an additional high quality test cock shall be provided at each pressure measuring point, for the connection of test instruments. It shall be possible to check and isolate the pressure instruments without disturbing piping or connections;
d) The Contractor shall supply and connect all piping and fittings to the instruments; and
e) The DC power supplies shall be supplied as loose items and shall be installed and wired by the Contractor.

30.6.8 Nameplates

A corrosion-resistant nameplate shall be permanently attached to the pump and contain the following information:

a) Manufacturer's name;
b) Year of manufacture;
c) Serial number of pump;
d) Size and type of pump;
e) Rated capacity in cubic metres per hour (m^3/h), litres per second (ℓ/s) or cubic metres per second (m^3/s);
f) Pump head at rated duty in metres (m);
g) Pump speed (rpm);
h) Maximum allowable casing working pressure in kilopascals (kPa);
i) Mass of complete rotating element in kg; and
j) Mass of completely assembled pumps in kg.

30.6.9 Flow switches

Flow switches are required at each pump’s suction side.

Standard paddle type flow switches sense liquid flow in either direction to monitor flow/no-flow conditions. The paddle is trimmed during installation to permit switch actuation at the minimum flow rate. As flow increases in a pipe, the paddle of the switch pivots to move out of the liquid path, producing less than 20 kPa of pressure drop regardless of pipe size.

Standard material is stainless steel with 1" BSP male end. The instrument shall be PN40 rated with an IP 65 enclosure and electrical requirement of 250 V, installed in a vertical, top of pipe position.

30.6.10 Number Plates

Each pumpset shall be provided with a number designation plate (baked enamel coated steel plate or equivalent) indicating the applicable Tag number as indicated on P&ID drawings, etc. The letters shall be at least 100 mm in height and the plate shall be mounted close to the pumpset in a position which is readily visible from inside the control room.

30.6.11 Cabling

Cabling shall be as specified in Section 39 – Electrical - Plant and Installation.

30.7 PAINTING AND CORROSION PROTECTION

Corrosion protection shall be as specified in Section 37 – Painting and Corrosion Protection.

30.8 HANDLING AND RIGGING

This Section should also be read in conjunction with Section 28 – Mechanical General.

The Contractor shall provide temporary end covers that adequately protect flanges and threads, and prevent damage to internal lining during transportation and during handling on Site.

The Plant and rigging equipment used by the Contractor for the handling and placing of pumps, motors, valves and pipes shall be such that no installed Plant is over-stressed during any operation. The pumps shall be so transported, stored, and handled that they are not overstressed at any time and are not damaged in any way. Special attention shall be given to the prevention of bearing and seal damages during transport. Pumps damaged or cracked in any way shall be repaired at a suitable workshop as agreed with the Engineer.

All heavy components designed to be dismantled and handled shall be provided with the following:

a) Rings, lugs, collars for lifting;
b) Slings, chains and special tools for handling; and
c) Special lifting screws, fitted at selected points and in sufficient numbers, for components designed to be uncoupled.

All custom made lifting equipment and cradles for the lifting of components and/or pumpsets necessary for installation or maintenance shall be provided by the Contractor and handed over to the Engineer on completion of the Contract.

30.9 INSTALLATION AND OPERATING REQUIREMENTS

30.9.1 Dewatering Plant (Sump Pumps) for Pumping Stations

30.9.1.1 General

Automatic, fully submersible dewatering sump pumps shall be wall mounted over a collecting sump fixed to the bottom of the sump pit inside any pumping station. High flowrate dewatering pumps shall drain the volume of water collected in the pumping station within an hour after a pipe or pipe joint failure from the period the pumping station isolation valve commence closing or preventing water reaching a level where it could damage the Plant installations against a minimum head of the 1:100 year flood level at the pumping station. Each floor drainage pump shall deliver flow suitable for the size and configuration of the pumping station against the 1:100 year flood level. The Contractor shall confirm the head of the pumps after calculating the friction losses through the valves supplied and the pipework to the outside of the pumping stations. The pumps shall be float or electrode controlled by the water level in the collecting sump and shall be of a reliable and robust type. Sump pumps shall be factory tested in accordance with BS Specifications Class C before transporting to Site.

Only hot dip galvanised pipework shall be used. Each pump shall have a dedicated discharge pipe. In line isolation valves are not required. Each pipe shall discharge water from the pump well into atmosphere outside the pumping station on the river side of the buildings.

The sump pumps shall be capable of handling dirty and sludgy water and shall be required to operate after empty dry sump periods. The pump intake shall be protected by either an adequately sized stainless steel screen capable of passing solids not more than 20 mm in diameter or the impeller shall have ample free passage as to eliminate the problem of clogging.

The switchboard of the dewatering Plant shall be located on the entrance level of the pumping station. The supply cable of the pumps shall be of sufficient length as to connect from the pumps to the control panel in one length.

30.9.1.2 Pump/Motor Unit Design

The pump and motor shall be fully submersible, capable of operating in a 1:100 year flood water depth in the Pumping Station and shall be a single unit with no shaft coupling between the pump and motor.

The sump pumps shall be of an automatic-coupling system that requires a base plate with a 90 degree bend, fixed to the bottom of the pit. Installation and removal of the sump pumps shall be done using the auxiliary hoist of the DGEOT. When lowered into the pit along the guide rails, the

pumps shall automatically connect to the base plate. There shall be no need for personnel to enter the sump to secure the pump in position. It shall be possible to remove either one (1) of the two (2) pumps for repairs without interrupting the operation of the remaining unit.

Sealing of the pump unit to the discharge connection shall be accomplished by a machined metal-to-metal watertight contact or flexible neoprene O-ring type seal situated in the pump discharge flange for ease of replacement. The connection between the pump and the auto-coupling shall ensure a leak-proof connection.

The floor drainage and dewatering pumps shall be required to operate continuously in ambient temperatures of up to 45 degrees Celsius. Motor cooling of the sump pumps shall be independent of the pumped liquid level, i.e. shall be equipped with cooling jacket, thus providing heat dissipation for the motor in case of the motor not being completely submerged in liquid. Impeller back vanes shall provide the necessary circulation of the liquid through the water jacket. The cooling media channels and ports shall be non-clogging by virtue of their dimensions. External cooling and seal flushing shall be provided.

30.9.1.3 Control and Alarm

Any rise in water level in the drainage sump above a predetermined level shall operate the floor drainage pump and at a predetermined sump-empty level the floor drainage pump shall stop, ready for the next drainage cycle. A continuous rise in water level above the floor drainage pump start level will alarm operations. The further rise of water in the sump will at a predetermined water level trigger the operation of the dewatering pump. Continued rise of water shall operate the station audible alarm indicating either a system malfunction or a non-functioning or malfunctioning of a sump pump.

30.9.2 Desilting Plant (Jet Pumps) For Removing Silt from Pump Inlet Hoppers

30.9.2.1 General

A venturi type jet pump system is required for removal of silt collected. The jet pump system shall be complete with motive water supply pump, motive water supply and slurry pipes, switchgear and controls.

30.9.2.2 Motive Water Pumps

Motive water pumps shall be installed in the dry well of the pumping station. Motive water pumps shall abstract water from the silt hoppers and connect to flexible motives water pipework outside dry well. Motive water pumps shall be suitably sized to meet the flow rate required by the jet pump. The motive water pump motors shall be immersible.

Motive water pumps shall be cycled to ensure similar run times. Motive water pumps shall be interconnected to improve redundancy. A standby motive water pump set shall be supplied as a spare part.

30.9.2.3 Motive water and slurry pipework

Motive water and slurry pipework shall be suitable for slurry type applications made from material suitable for transporting highly abrasive material. The motive and slurry pipework shall be flexible to facilitate lifting of the jet pump without having to disassemble pipework.

All slurry pipework shall be smooth with long radius bends to prevent potential blockages.

30.9.2.4 Jet pumps

A jet pump shall be selected and sized to abstract silt and other debris from any silt hoppers. The size of the material to be removed from the silt hoppers shall be aligned with the upstream screen opening.

Jet pump bodies to be constructed from painted corrosion resistant material such as 316 stainless steel or better suitable for extended and continuous submergence in water of quality as applicable. All jet pump components exposed to abrasive material shall contain hard iron inserts.

30.9.2.5 Accessibility, operation and maintenance

All components of jet pump system shall be accessible for ease of operation and frequent maintenance. As a significant part of the jet pump system will be submerged continuously, the inspection and maintenance of the jet pump system, especially in a silt hopper area, shall be as easy as possible. Adequately sized, permanently installed hoisting and lifting equipment shall be provided to lift jet pumps from the silt hoppers.

30.9.2.6 Operating philosophy

The jet pump system shall be operated predominantly during high flow events. During high flow events, the jet pump system shall automatically start for a pre-set time, adjusted from the SCADA/local control panel.

Jet pump systems shall also enable manual operation, operated from local control panel. Any failure of jet pump system shall be displayed on the local control panel/SCADA.

30.9.3 Placing on Concrete Plinths

The Contractor shall install the pumps, motors, valves and pipework on the completed concrete plinths, with holding down bolt pockets, constructed for the pumps, motors, valves and pipework.

Before positioning the pumps on their foundations the Contractor shall roughen the concrete surface, and ensure that all surfaces are free of all foreign materials, grease, oil, etc. The pumps shall be aligned as specified in Clause 30.9.4 before grouting commences.

The pumps shall be placed such that grouting clearances are maintained between the machine base, plinths and formwork.

30.9.4 Alignment

The Contractor shall align and level accurately the pump unit, using metal blocks and shims under the baseplate at the anchor studs and, in the case of heavy Plant, midway between studs. The anchor nuts shall then be drawn tight against the plinth. The pump and motor shall then be checked for alignment.

If alignment needs improvement, metal shims or wedges shall be added at the appropriate places under the baseplate. The Contractor shall align the units using laser beam alignment, and shall ensure that no measured deviation exceeds the smallest values recommended by the manufacturers of the motors, pumps and flexible couplings respectively. The readings shall be recorded and made available to the Engineer upon request.

The Contractor shall be responsible for filling the voids inside and between the baseplate and plinth with non-shrink grout.

The Contractor shall satisfy himself that the baseplate is fully supported over its whole length and that no voids have been left on the underside of any parts of the baseplate.

After the pumps have been in operation about one week, the foundation bolts shall be finally tested for tightness, the alignment checked (using clock gauges) and dowel pins fitted in the pump and motor feet.

When the grout has thoroughly dried (about 14 days after grouting), the exposed edges shall be painted by the Contractor using a suitable oil paint of the same colour as the pump baseplate.

30.9.5 Defects

Each pumpset and each piece of ancillary Plant shall be thoroughly cleaned and carefully examined for damage and defects immediately before installation. Should any damaged or defective pumpset or ancillary piece of Plant be installed, it shall be remedied by the Contracto.

30.9.6 Keeping Pump Sets Clean

Every reasonable precaution shall be taken during installation to prevent the entry of foreign matter and water into the pump(s).

30.9.7 Mounting

In addition to supplying and installing the pumpsets, the Contractor shall supply and install all appurtenant pipework and valves and he shall connect the pumpsets to the pipework. Pipework exerting unnecessary strain on pumps due to force fit will not be allowed.

30.9.8 Electrical Inspection

The Contractor shall check all items of electrical Plant for direction of rotation, correct phasing, motor and terminal voltage, and insulation resistance. The motor heaters shall be switched on for at least 5 hours immediately prior to running for the first time.

Before energising any of the motors for the purpose of commissioning, the Contractor shall measure the insulation resistance of each motor between phases and to the casing.

30.9.9 Glands / Mechanical Seals

Gland bolts shall be left completely loose and the final gland packing and tightening of gland bolts shall only be undertaken after the motors have been tested for direction of rotation and once the Plant is ready for commissioning.

Where mechanical seals are fitted and the pump design allows it, the motor couplings shall be disconnected during the initial dry run tests of the motors to ensure that the seals are not damaged.

30.9.10 Finishing and Painting

Finishing and painting and cleaning up the Site are regarded as inherent parts of the installation. On completion of erection, all pipework, control gear and indicating gear within the pump house shall be thoroughly cleaned.

Mechanical damages to paintwork caused by handling and during installation shall be repaired in accordance with Section 37 – Painting and Corrosion Protection. Final cosmetic application of polyurethane coatings shall be in accordance with the colour code as prescribed in Section 37.

The whole of the work shall be left in a clean and properly finished condition. All paints, and materials used in their preparation, shall be of the best quality of their respective kinds. All paint work shall be executed by tradesmen skilled in this class of work, and strictly in accordance with the paint manufacturer's product data sheets.

30.10 TOLERANCES

30.10.1 General

The standards laid down in this Section shall be adhered to in all cases unless the standards used by the Contractor are more stringent. In all cases where the Contractor deviates from the subjoined

standards, the Engineer shall be informed and only after acceptance by the Engineer can the alternative standards be used.

30.10.2 Shafts

The surface of the shaft (or sleeve) through the stuffing box shall not exceed a roughness of 32 rms (root mean square) and the pump shaft (or sleeve) shall be straight and any runout, as measured by a dial indicator, shall not exceed 0.0254 mm total indicator reading.

Dynamic shaft deflection measured under the worst conditions of load shall not exceed 0.050 mm maximum at the face of the stuffing box.

The balancing of all rotating Plant shall comply with the requirements of ISO 1940/1:2003 (Balance Quality Requirements of Rigid Bodies) using balance grade G1 or Balance Tolerance grade API. Complete test certificates shall be submitted for evaluation before assembly of the units.

The alignment of shafts shall comply with the requirements of BS 3170:1972. The shafts should be aligned in such a manner that both parallel and angular misalignment is eliminated. The acceptable alignment tolerance for parallel misalignment is 0.07 mm and for angular misalignment 0.07 mm / 100 mm.

30.10.3 Performance

Permissible variations from the required performance are as for Class B test in BS EN ISO 5198: 1999.

30.10.4 Vibration

30.10.4.1 Pumps

Vibration shall be measured at ± 10% of best efficiency flow in the radial and axial direction for vibration levels as specified in Table 30/1.

TABLE 30/1
ACCEPTANCE CRITERIA FOR HORIZONTAL PUMPS

FREQUENCY RANGE		AMPLITUDE Radial Direction (mm/sec, peak)	AMPLITUDE Axial Direction (mm/sec, peak)
Frequency	Related to RPM		
Overall vibration	Overall	3.5	1.8
Sub-harmonic	< 1 x RPM	0.6	0.6
Harmonic	1 x RPM	2.5	1.6
Lower frequencies	2 x RPM	1.5	0.9
Impeller-induced	(No of vanes) x RPM	1.5	0.7
Higher frequencies	(10 to 50) x RPM	0.95	0.95

30.10.4.2 Electrical Motors

Test data shall be taken on electrical motors running solo:

a) Motor to have a ½ key installed;
b) Motor to be placed on rubber mat at least 6 mm thick or free-hanging;
c) Where possible motor to be tested at full service speed;
d) Measurement must be taken in the horizontal, vertical and axial direction on each bearing (HVA);
e) Maximum amplitude of any peak in each frequency range to be recorded;
f) Maximum line amplitude is the amplitude value of the highest discrete frequency component within the stated frequency range in any direction (HVA); and
g) Factory test certificates from the motor manufacturer must be included with delivery.

TABLE 30/2
ACCEPTANCE CRITERIA FOR MOTORS > 370 KW

FREQUENCY RANGE		AMPLITUDE In Any Direction (mm/sec, peak)
Frequency	**Related to RPM**	
Overall vibration	Overall	2.5
Sub-harmonic	< 1 x RPM	0.6
Harmonic	1 x RPM	2.4
Lower multiples	(2 to 9) x RPM	0.9
Higher frequencies	(10 to 50) x RPM	0.3
Overall Acceleration	0 to 20 kHz	0.5 g at peak

30.11 FACTORY ACCEPTANCE TEST (FAT) AND PRE-COMMISSIONING

30.11.1 General Requirements

Inspection and Factory Acceptance Test (FAT) of pumps at the Factory shall comply with the general requirements as stipulated in Section 28 – Mechanical General as well as the following:

a) Where witnessed FAT or Site tests are required, the Contractor shall conduct trial test runs, and satisfy himself that the test results are in accordance with the requirements specified, before notifying the Engineer.
b) Any pump that requires segmental hydro test shall have the method of hydro testing fully described in the proposal.
c) If hydrostatic tests are performed with the shaft in position, the mechanical seals shall be removed and tests conducted with other types of seals or sealing methods.
d) The performance tests shall be carried out in strict accordance with Class B, BS EN ISO 5198. The vibration testing shall be undertaken by a suitable agency when requested by the Engineer.

e) The Contractor shall carry out the tests specified below and such additional tests in the Manufacturer's works, on the Site or elsewhere as in the opinion of the Engineer are necessary to determine that the Plant complies with this Section. Where mechanical seals are specified or form an integral part of the pumps installed under this Contract, all performance tests shall be conducted with the seals installed.

f) All instruments forming part of or used in the Plant shall be calibrated by an independent authority.

30.11.2 Factory Acceptance Tests (FAT)

30.11.2.1 Hydrostatic Pressure Tests

All pump casings shall be hydrostatically tested at the factory to at least 1.5 times the maximum possible working pressure of the pumps before any corrosion protection is applied without exhibiting signs of sweating, undue deformation and stressing, or defect of any kind. Hydro test shall be for a minimum period of 30 minutes. Through bolting, for the purpose of blanking the casing at the gland housing for pressure test purposes, will not be permitted.

Pumps manufactured in cast steel shall have their casting and test bars inspected and tested at the factory (the Contractor’s Works) in accordance with BS EN 10293: 2015 when the power absorbed by the pumps exceeds 250 kW and/or where the working pressure exceeds 1.6 MPa.

30.11.2.2 Performance tests

Performance test on all pumps shall be conducted before the pumps are transported to the Site.

The Plant provided by the Contractor to verify the guaranteed pump performance as specified in Clause 30.11.4, shall consist of the complete pump test rig including instrumentation to test the pumps in accordance with BS EN ISO 5198: 1999 Part 2 Class B at the pump manufacturers test rig.

Performance tests shall be conducted on all Duty Points specified. Performance tests shall include NPSH tests at the Duty Point with the highest flow rate.

All test bed testing shall be carried out under the supervision of competent and experienced staff, fully conversant with the test bed. Test measurements shall generally be carried out in accordance with BS EN ISO 5198: 1999 Part 1 Class B.

The motors shall be subjected to full load tests and test reports shall be available after testing; including loads expected at the rotational speed control limits of VSD range 60% to 110%.

A test manual, fully describing the test procedure as well as details of the calibration procedures and calibration interval of all instruments, shall be available at all times while the pumps are under test. The test manual shall include simplified explanations of all key points necessary on measurements,

datum corrections, calculations and all points to be considered in assessing mechanical integrity. The manual shall be sufficiently comprehensive to make it the only document required by test personnel.

Performance and vibration testing shall be carried out by the pump/motor manufacturer at a test facility agreed with the Engineer and witnessed by the Engineer. Certified test results, whether from the manufacturer's works or elsewhere, shall be provided to the Engineer before delivery.

30.11.3 Inspection and Pre-commissioning Tests on Site

30.11.3.1 Hydrostatic Pressure Tests

Pumps and pipework shall be hydrostatically pressure tested in situ by the Contractor to 1.5 times the working pressure for the pumps at their “duty point(s)”, or 1.3 times the pump shut-off pressure, whichever is the greater, by means of test equipment supplied by the Contractor.

Each test shall be carried out and certified by the manufacturer in the presence of the Engineer. The Contractor shall be responsible for all expenses incurred in carrying out all tests.

When carrying out the hydraulic test the Contractor shall ensure that all valves, tees and bends are properly secured and shored to prevent movement of pipes and fittings. Should any movement occur, the Contractor shall, at his own expense, reposition and, if necessary, repair the pipes and fittings and the securing means.

The specified test pressure for medium pressure pipework, valves, etc., (refer Section 32 – Pipes and Pipe Specials) shall be applied by means of a test pump. During the test, all pipes, specials, joints and fittings shall be carefully inspected for leaks. All visible leaks shall be made good and any pipe, special or fitting found to be defective shall be removed and replaced at the expense of the Contractor. Such replacement material shall, after installation, be tested at the expense of the Contractor.

Until the pumps, pipework, valves, specials and joints have shown zero leakage when subjected to the pressure test, the Plant will not be accepted. The test shall be repeated until the Engineer is satisfied that there is no leakage.

The above tests shall be complete and the test results submitted to the Engineer before any running tests are undertaken on Site.

30.11.3.2 Site Performance Tests

The equipment provided by the Contractor on Site to test the performance of the Plant shall include all the instrumentation not included in the permanent installation, (e.g. Watt meter, suitable pressure gauges, water meter of sufficient accuracy to ensure testing to BS EN ISO 5198: 1999 Part 1

Class C, and all tools and suitably trained staff. These tests shall include the Pre-Commissioning Tests and Plant Performance Tests as required in Section 48.

Two separate series of tests called the Preliminary Acceptance Test and Final Acceptance Test shall be carried out by the Contractor on all pumping units after installation. Test measurements shall generally be carried out in accordance with EN ISO 5198: 1999 Part 1 Class C and Section 48 - Tests on Completion.

30.11.4 Guarantees of Performance

a) The Contractor shall guarantee the output and efficiency of all machines, which guarantees shall be binding under the Contract.
b) The fulfilment of these guarantees shall be demonstrated at the Contractor's factory premises in accordance with BS EN ISO 5198: 1999 Part 2 Class B and shall be verified on Site in accordance with BS EN ISO 5198: 1999 Part 1 Class C.
c) All measuring instruments used in the tests shall have previously been certified by an independent testing authority, not more than one month prior to the test.
d) Where guaranteed performance is specified, certified test curves shall be drawn from the test data obtained from the purchased pumps and shall include; head (m), quantity pumped (m^3/h or ℓ/s), pump, motor & VSD efficiency (%), NPSH required (m), power consumption (kW), rotational speed (rpm) and speed/torque (rpm/kNm). The probable performance with maximum and minimum impellers shall also be indicated, as well as tested NPSH required.
e) Each pump shall be checked for acceptable vibration limits and noise limits.30.4.430.4.5

30.11.5 Liquidated Damages for Failure to Achieve Guarantees

The Contractor shall ensure that the pumps deliver the “Required minimum discharge” at each duty point, by fitting new impellers or taking whatever action is necessary should there be any non-compliance to the Employer’s Requirements in fulfilment of the Guaranteed Performance criteria.

Should the Contractor be unable to rectify the under-performance, liquidated damages will be payable as calculated by the Engineer based on the additional kW required.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 31

CRANES, HOISTS AND WINCHES

TCTA MODULAR STANDARDS

SECTION 31
CRANES, HOISTS AND WINCHES

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SECTION 31
CRANES, HOISTS AND WINCHES

31.1 SCOPE, DEFINITIONS AND STANDARDS

31.1.1 Scope

This Section covers all permanent cranes, hoists and winches that are included in the Works.

This Section must be read in conjunction with Section 28 - Mechanical General, Section 38 - Electrical General, Section 37 - Painting and Corrosion Protection as well as Section 48 - Tests on Completion.
The scope of work shall include the design, supply of all materials, manufacture, shop assembly and testing, corrosion protection, delivery to Site, off-loading and installation at Site, Site painting, testing, pre-commissioning and maintenance (other than normal operating maintenance) of the Plant.

All cranes, lifting beams and hoists shall include at least the following:

a) Lifting hooks that shall raise and lower vertically on centre;
b) Non-spin wire rope and fitted sheave block with swivel hook;
c) Slack rope switch on electrically operated cranes;
d) Load cell controlled overhead cut out;
e) Motorised cross and longitudinal drives;
f) Proximity limit switches on all crane motions protected in accordance with IP 65 of SANS 60529 on all electrically operated cranes;
g) Festoon cable, tracks and mountings for cross travel on all electrically operated cranes;
h) Push button pendant control all weatherproof and protected to IP 65 of SANS60529;
i) Remote radio push button control;
j) Electrical distribution box with isolator fully weatherproofed and protected in accordance with IP 65 of SANS 60529. The cabinet door(s) shall be fitted with suitable seals to prevent the ingress of water;
k) Crane long travel rails and appropriate temporary and permanent fixings with stop bumpers at both ends;
l) Cross travel rails with stop bumpers at both ends;
m) Positive locking devices to store the portal crane at any point on the rails;
n) Power supply between the isolator box and the crane distribution box. This shall include the conductor bridge rail system as well as all switch gear;
o) Suitable weatherproof floodlights for lighting the whole area beneath the crane;
p) Crawls, block and tackles;
q) The complete conductors system and fixtures;
r) Operation and Maintenance Manuals which shall include drawings and copies of all shop and field test certificates.

31.1.2 Definitions

The following terms shall have the meanings given:

a) **"Main hoist"** means the hoist mechanism provided for lifting the maximum rated load.
b) **"Auxiliary hoist"** is a supplemental hoisting unit on the crane of lighter capacity and unusual higher speed than provided by the main hoist.
c) **"Trolley"** is the unit which travels on the bridge rails and carries the hoisting mechanisms.
d) **"Runway"** means an assembly of rails, beams, girders, brackets, and framework on which the crane or trolley travels.
e) **"Walkway"** means the stationary walkway that runs the full-length of the pump station and forms an integral part of the superstructure of the building.
f) **"Footwalk"** means the walkway with handrail, attached to the bridge or trolley for access purposes.
g) **"Bridge"** means the main travelling structure of the crane which spans the width of the pump station consisting of girders, end trucks, footwalks, and drive mechanism which carries the trolley.
h) **"End trucks"** are located on either side of the span housing the wheels on which the entire crane travels. These wheels ride on the runway beam allowing access to the entire length of the pump station.
i) **"Holding brake"** is a brake that automatically prevents motion when power is off.
j) **"Bumper"** [buffer] is an energy absorbing device for reducing impact when a moving crane or trolley reaches the end of its permitted travel.
k) **"Clearance"** means the distance from any part of the crane to a point of the nearest obstruction.
l) **"Rope"** refers to wire rope.
m) **"Span"** means the horizontal distance centre to centre.
n) **"Emergency stop switch"** is a manually or automatically operated electric switch to cut off electric power independently of the regular operating controls.
o) **"Limit switch"** is a switch which is operated by some part or motion of a power-driven machine or Plant to alter the electric circuit associated with the machine or Plant.
p) **"Main switch"** is a switch controlling the entire power supply to the crane.
q) **"Long travel"** means the crane movement in a direction parallel to the crane runway also known as "bridge travel".
r) **"Cross travel"** means the trolley movement perpendicular to the crane runway also known as "trolley travel".

31.1.3 Standards

The following Standards and Codes of Practice are referred to in this Section:
Fédération Européene de la Manutention (FEM), Rules for the Design of Hoisting Appliances, Section 1, Second Edition, 1970.

South African National of Standards

SANS 44:2009	:	Welding Consumables
SANS 121	:	Hot-dip galvanised coatings on fabricated iron and steel articles
SANS 142:2012	:	Narrow Elastic Fabrics and Strip
SANS 1431	:	Weldable Structural Steel
SANS 10044	:	Welding
SANS 1700	:	ISO metric precision hexagon-head bolts, screws and nuts (coarse thread medium fit series)
SANS 4310:2002	:	Cranes – Test Code and Procedures
SANS 60529:2013	:	Degrees of protection provided by enclosures (IP Code)

British Standards Institution

BS EN 50149:2012	:	Railway applications. Fixed installations. Electric traction. Copper and copper alloy grooved contact wires
BS 46-3:1951	:	Keys and keyways and taper pins. Specification for solid and split taper pins for general engineering purposes
BS 970-1:1996	:	Specification for wrought steels for mechanical and allied engineering purposes. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels
BS 436-5:1997	:	Spur and helical gears. Definitions and allowable values of deviations relevant to radial composite deviations and runout information
BS 721-2:1983	:	Specification for worm gearing. Metric units
BS EN 1993-6:2006	:	Eurocode 3. Design of steel structures. Crane supporting structures
BS EN 1677-5:2001	:	Specification for higher tensile steel hooks for chains, slings, blocks and general engineering purposes
BS EN 13889:2003	:	Forged Steel Shackles for General Lifting Purposes
BS EN 13157:2004	:	Cranes. Safety. Hand powered lifting equipment
BS EN 12385-1:2002	:	Steel Wire Ropes. Safety and General Requirements
BS 1663:1950	:	High Tensile Steel Chain Grade 40 for Lifting Purposes

German Institute for Standardisation

DIN 536-1	:	Crane Rails, Hot Rolled Flat Bottom Crane Rails (Type A)
DIN 15400	:	Lifting hooks, materials, mechanical properties, lifting capacity, stresses
DIN 15401: Part 2	:	Lifting hooks for lifting appliances, single hooks
DIN 15402: Part 2	:	Lifting hooks for lifting appliances, rams horn hooks (double hooks)

American Welding Society

AWS D14.1	:	Welding of Industrial and Mill Cranes

American Society of Mechanical Engineers

ASME HST-4	:	Performance Standard for Overhead Electric Wire Rope Hoists

ASME B30.2 : Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)

South African Electrolytic Corrosion Committee
Code of Practice No. SAECC/1
ANSI B31.3

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

31.2 DESIGN AND OTHER GENERAL REQUIREMENTS

31.2.1 General

The Plant shall be supplied with all the accessories necessary to provide complete working installations including all built-in parts and anchors, rail tracks, hoists, covers and frames, operating gear, controls and safety devices and electrical control panels from and including the main isolating switch on the incoming supply.

During installation of lifting equipment the Contractor shall comply with Construction Regulation 19 – Hoist General machinery Regulation 3 - Safe guarding of machinery, General Machinery Regulation 4 - Operation of machinery, General Machinery Regulation 6 - Devices to start and stop machinery, Driven machinery Regulation 18 - Lifting machines, lifting devices and lifting tackle, Electrical machinery Regulation 6 - Switch gear, Electrical machinery Regulation 7 - Electrical control gear, Electrical machinery Regulation 8 - Switchboards and Electrical installation Regulation.

The Contractor shall ascertain that the capacity of the main hoist is suitable for safely lifting double the weight of any part of the mechanical Plant in the area serviced by the crane – the Safe Working Load. The required capacity of the main hoist shall be communicated to the designer prior to the commencement of the design of the crane.

The load capacity of the crane shall be clearly displayed on both sides of the bridge as well as on the sheave block e.g. SWL 12 500 kg.

All civil construction work in forming and preparing box outs, chases etc., to receive the built-in parts and in placing concrete around them or grouting in base plates and holding down bolts and the like shall be done by the Contractor.

The Contractor shall be responsible for the coordination and proper relation of all work to the building structure and to the work of all trades. The Contractor shall determine and verify all physical dimensions of the building proper that relate to runway alignment, crane fabrication and all other requirements under this Section as, during the course of construction of the building and superstructure, as-built dimensions may deviate from the intended dimensions shown on the drawings. It shall be the Contractor's responsibility to be aware of the possible dimensional tolerances permitted for construction and to bring these to the attention of the crane supplier.

31.2.2 Double Girder Electrically Operated Overhead Travelling Cranes (DGEOT)

The type of crane servicing proposed pumping stations shall be top running (T/R) double girder bridge cranes. This means that the cranes shall consist of two bridge girders supported on two end trucks and a trolley that shall run on rails on the top of the bridge girders.

DGEOT cranes are required primarily for maintenance operations in the pumping stations and lifting of Plant off and onto vehicular transport parked on the pumping station loading bays as well as into its permanent positions.

The DGEOT cranes may also be used during the installation phase of the pumping stations.

The Contractor shall during the design stage confirm the required lifting capacities of any DGEOT cranes and inform the Engineer.

Maximum hook height for the main crane hoist shall be 6 meters above the loading bay level and a hook travel path down to the pump well.

DGEOT cranes shall be fitted with a 2 metric tonne auxiliary hoist with a maximum hook height 6 meters above the loading bay level and a hook travel path down to lowest sump pit. The 2 tonne auxiliary hoist will be used for general operations and maintenance and lifting and lowering of water cooling pumps/motors, smaller valves and sump and dewatering pumps.

The capacity of the cranes shall be sufficient to handle the specified safe working load (SWL) plus an additional 10%.

31.2.3 Electrically Operated Portal Cranes

Portal cranes are required primarily for deploying stop logs and for the handling of the radial and sluice gates as well as the trash racks and fine screens located at abstraction works and the Plant to be hoisted from their position to above the operating top deck level and on to appropriate road transport, and vice versa. It will furthermore be required for any other maintenance operations carried out.

The type of crane shall be electrically operated rail-mounted type portal crane with a maximum hook height above operating deck level as described below and a hook travel path to the lowest sedimentation canal or trap level.
The capacity of the crane shall be sufficient to handle the heaviest of the Plant described below plus an additional 10% but shall have a Safe Working Load of not less than 10 tonnes. The maximum hook height above deck level shall be the maximum total suspended height of the Radial and Sluice Gates, Stop Logs or Trash Racks plus an additional 600 mm minimum.

A 2 ton auxiliary hoist unit shall be provided on any cranes for the purpose of handling Plant of lighter capacity and fine screens. This unit shall be mounted on the same trolley as the main hoist and shall be appropriately sized for handling one fine screen containing 80 kg of trash at a time and for general maintenance and operational use.

The auxiliary hoist shall comply in all respects with the general requirements of this Section with the only exception that it does not require a load cell indicator. The lifting ranges shall be equal to that of the main hoist.

Cantilevered ends of the beam shall be provided and dimensioned to allow the handling of Plant for safe loading and off-loading to appropriate road transport. The total cross travel distance shall be determined in accordance with the Plant to be serviced.

The cantilever shall be designed so that the crane hook can reach the midpoint of radial or sluice gates and the midpoint of stop logs.

The crane shall be sized and configured so that the hook can be raised high enough to pass over any hoist gantries or as they are normally deployed.

If counterweights are required in order to stabilise the crane under the test load at the limits of travel, then these shall be of solid material; i.e. water ballast is not acceptable. If the counterweight is bolted on, then this shall be of metal or reinforced concrete slabs.

A cow catcher shall be provided at each of the four wheels. The cow catcher shall be designed to push a person’s foot and, thereby, prevent injury during movement of the crane in the long travel direction. The cow catcher shall, in addition, be provided with a flat, horizontal top surface onto which a person can climb if required.

The long travel, i.e. the Portal Crane legs’ wheel movement; shall be stopped approximately one metre before the end of the rail beam so that a person can safely stand beyond that position.

An appropriately sized auxiliary hoist shall be used for cleaning operations of the trash racks and fine screens.

The portal crane may also be used during the construction for the installation of gates, racks and screens as well as any hydro mechanical Plant.

31.2.4 Monorails and Crawl Beams

Inside pumping stations, the Contractor shall ensure that the need for crawl beams are avoided and that all Plant are accessible through the DGEOT with auxiliary hoists.

Monorails for operation and maintenance of sluice gates, trash racks and fine screens as well as stop logs not readily serviced by a portal crane may be provided in liaison with the designer of the gates.

31.3 MECHANICAL DETAILS AND REQUIREMENTS

31.3.1 General

The cranes and hoists shall be, as far as possible, of a manufacturer's standard type with long and cross travel and shall comply with the Occupational Health and Safety Act (Act 85 of 1993) and Construction Regulations 2014.

The minimum hook to deck level clearance shall be as determined by the designer.

The limits at which the crane can safely handle loads of full load capacity shall not be less than required and specified above.

31.3.2 Electrical Cranes and Hoists

The electrically powered crane shall be designed in accordance with *Fédération Européene de la Manutention (FEM)*, *Rules for the Design of Hoisting Appliances, Section 1, Second Edition, 1970* with the following duty factors:

Structures	Cranes, Hoists, etc.	
Class of utilisation	A	
State of loading	2	
Group	3	
Mechanisms (all motions)		
Class of operation	$V_{0.5}$	V_2
State of loading	3	2
Operating Group Classification	$1A_m$	2_m

31.3.3 Factors of Safety

All parts of the cranes, hoists and lifting devices shall be designed to a factor of safety of at least 4 when working under full load conditions. Lifting ropes and attachments shall have a factor of safety

of at least 6 when working under full load conditions. The term “full load” shall be the maximum working load rating specified for each hoist.

31.3.4 Mechanical Chain Blocks

Hand operated hoists and runway beams shall be in accordance with BS EN 1993-6:2007 and BS EN 13157:2004 where applicable. Chains shall be in accordance with BS 1663:1950 and hot-dip galvanised in compliance with Section 37 - Painting and Corrosion Protection.

31.3.5 Hooks and Shackles

The hook assembly shall be carried on antifriction bearings to permit free swivel under rated capacity load. The hook shall be fitted with a spring-loaded safety latch to prevent the disengagement from the hook of the lifting wire, chain or rope to which the load is attached.

The crane hook shall fit freely onto the lifting point of all grappling- and lifting beams / cradles used to lift the fine screens, gates, pumps, etc., in the specific part of the Works serviced by that particular crane.

The following standards shall apply to hooks and shackles:

a)	Ramshorn hooks	DIN 15402 Part 2;
b)	Standard hooks	DIN 15401 Part 2; and
c)	Shackles	BS EN 13889:2003.

31.3.6 Runway Beams

Runway beams and long travel rails shall be installed in accordance with the drawings provided by the designer. The long travel rails for the portal crane shall be set flush with the deck. Where vehicles may transgress rail ends, the end of the rail shall be provided with a protective cage formed from DN 150 steel tubing which will form a primary barrier preventing damage.

The cranes shall clear all walls and other constraints by a minimum of 100 mm.

31.3.7 Rails and Resilient Pad

All long and cross travel rails shall be in accordance with DIN536-1 (or equivalent); i.e. flat-bottomed rails and assembled as per German Standard VDI 3576 (or equivalent). Rails shall be installed complete with end stops, clamps, anchor bolts, fish plates etc. and shall be designed to permit expansion and contraction.

The runway rails shall be secured to the runway beams using specially designed clips and HSFG bolts suitable for the size of crane rails to be used. The rail clips should be installed in a staggered arrangement with 600 mm minimum and 750 mm maximum distance from centre-to centre. Rail

clips should be capable of allowing lateral adjustment to the rail to facilitate initial alignment and subsequent realignment. However, the adjustment should be limited to the size of the girder in order to avoid excessively eccentric application of the vertical wheel load to the girder, which could produce transverse bending stresses in the web and the flange-to-web weld.

All rail section lengths shall be welded together to give a continuously welded rail between expansion joints, the welded method shall be either by Flashbutt (resistance) or Aluminothermic method. The Contractor shall submit the necessary Welding Procedure Specification (WPS) and Welding Procedure Qualification Record (WPQR) for approval by the designer and review by the Engineer before commencing with the works.

Proprietary resilient soft mounting pads should be placed under the runway rails to allow for redistribution of concentrated wheel load, reducing impact, vibration and noise, and eliminate of fretting action. The pads shall be manufactured from a synthetic elastomer especially resistant to wear, shear and crushing as well as oil, grease, ozone, and ultra violet rays. The pad shall be reinforced using a high strength galvanised steel strip that covers at least 90% of the width of the pad, and fully vulcanised to the rubber.

Where applicable, runway rails will be grouted into position in pre-formed slots after alignment on pre-installed bed plates (primary built-in parts) by the Contractor. The pre-installed parts, with details, shall be supplied by the crane manufacturer for installation by the Contractor.

31.3.8 Bridge Girders

Crane bridge girders shall consist of welded sealed sections with sufficiently reinforced construction, of approved design and supported on the end trucks and having ample stiffness in all directions. The maximum vertical deflection of the girders shall not exceed 0.002 times the effective span with the trolley carrying full load positioned at the centre of the span. The Contractor shall submit the necessary Welding Procedure Specification (WPS) and Welding Procedure Qualification Record (WPQR) for review by the Engineer if requested.

31.3.9 Trolley

The trolley shall be fabricated as an integral part of the hoisting mechanism or as an assembly bolted to a unit hoist. The trolley frame shall be of welded or cast steel construction. It shall furthermore be of rigid construction designed to transmit the imposed load to the bridge girders without undue deflection.

The trolley deck shall as far as practicable be covered with chequer plate for maintenance and access purposes. Hardened, heat treated, double-flanged steel wheels with anti-friction bearings shall be provided. The trolley shall be motor-driven through a suitable gear reducer. An electric brake shall be furnished on this drive. The drive shall be shock free on starting and stopping. The arrangement and details of the trolley shall be subject to the review of the Engineer.

31.3.10 End Trucks

Each end truck shall be supplied with large diameter, heat treated, double-flanged steel wheels and shall be of the fixed axle type equipped with anti-friction bearings. The end trucks shall be one piece welded construction bolted to the bridge beam and designed so that the weight of the crane and its load is equally divided between the wheels. These shall incorporate suitable drop stops to limit the fall of the crane to less than 25 mm in the event of breakage of a track wheel, bogie or axle bringing the crane to a safe stop.

31.3.11 Bumpers

The bumpers shall have sufficient energy absorbing capacity capable of stopping the crane at each extreme end of the crane travel.

31.3.12 Hoists

The hoist units shall be of the electric top running motorised type and trolley combined in one unit providing accurate load positioning with a load capacity and lift range as specified above. The hook shall raise and lower vertically on centre.

Suitable load cells (minimum 125% of specified capacity) shall be incorporated in the main hoist design to reflect the true load being manipulated by the crane at any time.

The hoists shall have at least two independent means of braking, a holding brake which shall be applied automatically on power removal and controlled braking to prevent speeding when lowering the load.

31.3.13 Drums and Pulleys

The rope grooves in drums and pulleys shall be machined as follows:

The diameter of the drum measured at the bottom of the groove shall not be less than that given in the table below which is based upon the rope speed not exceeding 60 m per minute.

TABLE 31/1
DRUM DIAMETERS

Rope construction	4 x 37	6 x 19	6 x 24	6 x 37	6 x 61
Drum diameter	27D	24D	22D	19D	17D

D = Diameter of rope

The contour at the bottom of the grooves shall be circular over an angle of approximately 120°.

The radius of the groove shall be larger than the radius of the rope and not less than that required by BS EN 12385-1:2002+A1:2008 or equivalent standard. The depth of the groove shall not be less than:

- Drums: 0. 33 x diameter of rope;
- Pulleys: 1. 05 x diameter of rope; and
- The edges shall have a radius.

The grooves shall be finished smoothly and be free from surface defects liable to damage the rope. The grooves on the drum shall be so pitched that there is a clearance of not less than 1.6 mm between the neighbouring turns of rope for 13 mm diameter rope, 2.5 mm for 13 mm to 28 mm and 3.2 mm for rope diameters above 28 mm.

The drums shall be of sufficient length to take the full amount of rope without overlapping when the load is at its highest position. When the load is in its lowest position, there shall be at least two full turns of rope remaining on each drum.

The method of anchoring the ropes, as described below, shall be such that in the event of a rope unwinding completely there shall be no danger of it becoming freed from the drum. The rope anchorage shall be readily accessible.

Pulleys in the sheave block shall be equipped with close-fitting guards that will prevent ropes from becoming fouled when the sheave block is lying on the ground with ropes loose.

All running pulleys shall be equipped with means of lubrication. Permanently lubricated, sealed and/or shielded bearings will be acceptable.

The inclination between the rope and the plane perpendicular to the axis of the drum or pulley shall not exceed 1 in 12.

Rope drums shall be adjustable for rope stretch if balancing pulleys are not used.

Particular attention shall be paid to the design and positioning of the rope drums(s) to ensure a centre lift over the lifting points for the sluice gates and fine screens when raising and lowering these items of Plant and that the ropes and sheave block do not foul the wall at the extreme point of lowering.

31.3.14 Sheave Block

The sheave block shall be designed to suit the load.

31.3.15 Rope

Ropes shall be capable of supporting the maximum loads during lifting and lowering operations. The minimum breaking strengths of the ropes shall not be less than 6 times the respective maximum load. The ropes shall be impregnated with grease to resist corrosion and wear.

Where more than one fall of rope is used for the support of the load, the tension in the various parts shall be equalised by means of a pulley or equalising bar.

Eye splices, sockets, thimbles and rope anchorages shall be capable of withstanding 90% of the guaranteed breaking strength of the ropes to which they are attached. The hoisting ropes and any slings shall be provided with a test piece to be cut for testing to destruction.

The rope end(s) shall be anchored by a clamp securely attached to the drum, or by a socket arrangement in a suitable manner such that the tension of the rope comes on the anchor points as near tangentially as possible. Anchoring shall be of captive type, easily detached for changing and repair. Rope end(s) shall be tapered and fused.

The Contractor shall ensure that all the spin in the wire rope is removed prior to final fixing of the rope to the crane body or drum(s). To achieve this “spin free” state, he shall inter-alia, lower the sheave block to its bottom extreme as part of the installation procedure.

31.3.16 Crawl Beams (where applicable)

Crawl beams shall be designed to BS EN 1993-6:2007 including UK National Annexure to Eurocode 3. The capacity of each beam shall be displayed as described in Clause 31.2.1. Each crawl beam shall be equipped with removable stops at each end, a manually operated geared crawl with operating chain which shall correspond with the beam capacity and a manually operated block and tackle type chain hoist of the specified capacity.

31.3.17 Crane Speeds

The speeds of the various motions of the crane shall be as follows:

a) Long and Cross travel - creep: 5 m/min;
b) Long travel - fast: 35 m/min to 40 m/min;
c) Cross travel - fast: 18 m/min to 25 m/min;
d) Hoist - creep: 1.0 m/min to max 2.0 m/min; and
e) Hoist - fast: 6 m/min to 10 m/min.

All hoisting motions shall be electronically “ramped” so as to minimise impact/acceleration loadings (see also Clause 31.4.9).

31.3.18 Auxiliary Hoists

Auxiliary hoist units of 2 ton shall be mounted on the same trolley as the main hoist and shall be appropriately sized for handling one fine screen, water cooling pumps/motors, sump and dewatering pumps and smaller valves for general maintenance and operational use.

The auxiliary hoist shall comply in all respects with the general requirements of this Section with the only exception that it does not require a load cell indicator. The lifting ranges shall be equal to that of the main hoist.

31.3.19 Gearing

Gears shall be designed so that all stresses are within the permissible limits when the hoists are handling the maximum load. Spur gears shall be of high-grade steel with precision cut, full depth teeth for accurate fit and splined for fitting to the mating gear. All gears shall be quiet in operation when rotating in either direction. The gears shall have a factor of safety of not less than 6 under operating conditions. For determining this factor of safety, the formula given in BS 436 or equivalent standard shall be adopted. If the gears are based on BS 436 they shall be calculated for not less than 4 working hours per day.

Where worm gearing is used as a first motion drive, it shall be at least equal to BS 721-2:1983 or equivalent standard and have the same lead and start time rating as the motor and the temperature rise of the oil bath shall not exceed 37° C above the ambient temperature. Worm wheels shall be of bronze with steel worms.

All gear wheels shall, where practicable, be a forced fit on the shaft and shall in addition be adequately secured to prevent any relative motion between the wheel and the shaft. Where gears and couplings are secured in position by means of keys, the keys shall be easily accessible for tightening or withdrawal. All keyways shall be machine cut and shall be at least equal to BS 46-3:1951 or equivalent standard. Couplings and collars shall be of the shrouded or protected type, free from projections of any kind. All shafts shall be of adequate diameter and of suitable material for the purpose and shall be turned where necessary. Where shoulders occur, they shall be provided with adequate fillets.

Gear-train assemblies shall be carried on antifriction bearings and enclosed in the hoist frame casting. The assemblies shall operate in a sealed oil bath. Frame casting shall be provided with lubrication fittings and inspection ports.

31.3.20 Canopy for Hoist Unit

The hoist units shall be covered by a weatherproof canopy to protect it from dust and rain, regardless whether it is installed indoors or outdoors.

The canopy shall be manufactured from aluminium or stainless steel. Its design shall incorporate lockable panels on the sides and at the top, which can hinge open to allow access for maintenance. Hinges shall be of stainless steel. The panels shall be lightweight in order to facilitate easy handling. Built-in struts shall be provided to keep flip-up covers in the open position.

31.3.21 Footwalks

Access ladders with safety cages shall be provided at both ends of the pumping station allowing access to access platforms or the concrete roofs of the rooms inside the pumping station from floor level. Further access to the crane for maintenance purposes shall be with a ladder that forms an integral part of the crane bridge, to one of the footwalks. The conductor power rail system shall, from a safety point of view be secured on the opposite side of the building.

For portal cranes, an access ladder with safety cage shall be provided. The access trapdoor, if any, shall be fitted with a catch to lock it in the open position.

Full-length footwalks shall be provided on both sides of the crane bridge for access to the festoon cables, floodlights and to facilitate easy access to all maintenance points and electrical Plant. A cross-over platform secured to the trolley shall be provided between the two footwalks so as to allow safe access to the trolley between the two footwalks.

Footwalks shall be furnished complete with hand and knee railings and kick plates as required by the OHS Act and its regulations. The footwalks shall be provided such that personnel standing on them will not be exposed to the danger of colliding with obstructions due to the movement of the crane.

Footwalks shall be located to give headroom of not less than 1 990 mm. Footwalks shall be of rigid construction and designed to sustain a distributed load of at least 75 kg per square meter. Footwalks shall have a walking surface of anti-slip type, i.e. checker plate or equivalent and shall be continuous and permanently secured. Drainage holes of minimum 20 mm diameter shall be provided at the required locations to prevent the collection of water on footwalks and or platforms and the prevent corrosion.

Supply and installation of these footwalks, ladders and platforms form part of this Section.

31.3.22 Guards

If hoisting ropes run near enough to other parts to make fouling or chafing possible, guards shall be installed to prevent this happening.

Exposed moving parts such as gears, set screws, projecting keys, pulleys and reciprocating components which might constitute a hazard under normal operating conditions shall be guarded to prevent this happening.

31.3.23 Lubrication and Maintenance

Adequate provision shall be made for grease gun and oil lubrication and all lubricating points shall be easily accessible. Grease nipples shall be of the stainless steel button head type (1/8" BSP) and shall, together with oil filler caps or plugs, be painted red for easy identification.

Maintenance procedures shall be in full compliance with the Occupational Health and Safety Act (Act 85 of 1993) and its regulations.

Effective means shall be provided for lubricating all moving parts with either oil or grease.

Lubrication of all lifting ropes shall be in accordance with Section 37 - Painting and Corrosion Protection.

Refer to Clause 31.11 for services and maintenance required during period of initial use by the Contractor.

31.3.24 Bolts and Nuts

All exposed fasteners, including those used for the fixing of proprietary items to the crane girders and bridge, shall be of stainless steel grade 304 or better. Where strength requirements prohibit this, bolts shall be hot dip galvanised in accordance with SANS 121 and shall comply with Section 28 – Mechanical General.

31.3.25 Chevrons

For the portal crane, suitable luminous type chevrons shall be painted, or mounted with stainless steel bolts, on the two sides facing the direction of long travel of each portal frame leg. The chevrons, to be mounted on the portal legs, shall extend 2 m high from the bottom of the leg.

Suitable chevrons shall be neatly painted in a diagonally black-and-yellow stripe pattern on both sides of the sheave blocks of all cranes.

31.4 ELECTRICAL DETAILS AND REQUIREMENTS

31.4.1 General

The electrical systems of the crane and hoists shall be in accordance with Section 38 – Electrical General and as further described hereunder.

The electrical Plant shall comprise the operating motors with their controllers and resistances, brake-magnets, limit switches, lighting, main switches, fuses, anti-condensation heaters, crane bridge conductors and the collectors required for supplying power to the crane.

Control systems shall be designed to achieve the operational requirements stated. In particular the controllers shall allow smooth operation without jerk or snatch on all motions from standstill, each controller being provided with an adequate number of steps in either direction to achieve smooth acceleration or retardation.

All components of the control system shall operate with adequate safety margins to ensure reliable operation under all conditions of service with the minimum of maintenance.

31.4.2 Power Supply

The power supply and main isolator box with isolator shall form part of the general electrical installation to be provided by the Contractor. Cabling from this isolator box to the crane forms part of the scope of work for the components of this Plant item.

31.4.3 Power Transfer to Plant

All isolators for power transfer systems shall be heavy duty and suitable for outdoor service.

31.4.4 Crane Bridge and Runway Electrification

Electrical supplies to the portal crane shall be by means of a trailing cable system. The transfer system shall further be located along the long travel rail on the opposite side to the vehicle access in order to avoid damage caused by traffic coming onto the working area below the crane. A cable trailing trench shall be supplied to the requirements of the crane supplier.

Power supply to the runway electrification of travelling cranes in the pumping stations shall be by means of bridge conductors and collector system. The transfer system shall further be located along the runway rail on the opposite side of the pumping stations to the access ladders as described above.

The length of the power transfer mechanisms shall enable the crane to travel the full length of the area served by the particular crane.

The minimum requirements for the power transfer system, regardless of the type and crane location, shall be:

a) Minimum of four conductors with separate earth conductor. Should it be required to have a neutral conductor due to possible phase imbalance, this must be provided;
b) Weather resistant and suitable for outdoor service in a humid atmosphere;
c) Trailing cables shall be provided with an automatic cable spooling reel with tensioning device and with a strain restrictor at each end of the cable;
d) Conductor bars shall be one piece, copper conductor complete with thermoplastic insulation covers and end covers to provide adequate personnel safety features and shall be protected against falling objects. Protection covers shall be easily removable for maintenance purposes;

e) The conductor rail systems shall be through longitudinal conductors with moving pick-up arms having physical and electrical properties complying with BS EN 50149: 2012. Collector shoes and assemblies shall be spring-loaded;
f) A triple pole, metal clad, airbreak isolator switch incorporating "On", "Off" and "Earth" positions, shall be supplied for isolating the main power supply to the crane and for earthing the longitudinal conductors;
g) All isolators for power transfer systems shall be heavy duty and suitable for outdoor service; and
h) Conductors shall be accurately aligned to ensure positive electrical contact over the full length between the collector and the conductor.

31.4.5 Hoisting Trolley Electrification

Power supply to the hoisting trolley shall be by means of a multi-stranded, festooned flexible flat cable suspended from a catenary system on C-track. The festooned cable shall be connected to the termination box at one end of the bridge and to the pendant control unit on the C-track.

31.4.6 Electrical Distribution Box

A lockable 316L electrical distribution box, protected in accordance with IP 65 of SANS 60529:2013, shall be supplied and installed on the crane by the Contractor. It shall contain an isolator having provision for padlocking in the "OFF" position. It shall also have provision for the hanging of a "MAN WORKING" notice, which shall be included with the supply of the crane.

Three red indicating lamps, marked L1; L2 and L3 (one per phase and which shall illuminate when the supply is on), shall be provided on the distribution box. These indicating lamps shall be of the 230 V LED multi-cluster type and shall be clearly visible in normal daylight.

A danger sign shall be provided and fixed onto the distribution box.

31.4.7 Electric Motors

All motors shall be of the totally enclosed fan cooled squirrel cage type. Their characteristics and construction shall be suitable for outdoor crane service.

Hoist motors shall be capable of continuous operation under full load at normal speed as well as limited duration operation on "inching" duty.

The three-phase motors of the crane shall have the correct phase rotation of the power supply after the Site wiring and connections have been completed.

Separate motors shall be provided for the hoisting, long and cross travelling motions, each motor being independent of the others.

31.4.8 Control Panel

All crane control gear shall be enclosed in a lockable 3CR12 cabinet mounted in a suitable position on the crane in such a manner as will facilitate easy maintenance and inspection.

Control and operating circuit voltages shall not exceed 230 V AC. All motor control and starters shall make use of circuit breakers and thermal overloads. The supply to the control panel shall be 380 V plus neutral.

Contactor control gear shall include for each drive a triple pole electrically and mechanically inter-locked stator reversing contactor fitted with self-resetting adjustable inverse time characteristic over-current relays.

The electrical load on the three phases shall at all times be balanced.

31.4.9 Pendant and Remote Radio Control

The cranes shall be operated by means of a weatherproof pendant control by an operator standing on the operating level. The pendant shall be capable of being positioned at any point over the length of the girder independent of the trolley. The pendant unit shall be suspended from an independent wire rope. All the features required of the pendant control in this section shall also apply to the remote radio control. Precise control of all functions is required to facilitate the accurate positioning of heavy components.

The complete pendant with all switches, indicators, etc., shall be weatherproof to IP 65 of SANS 60529:2013.

Long and cross travel motions of the cranes shall be arranged so that these motions may be driven simultaneously or separately without causing shock to or vibration of the crane rails. It shall not be possible to travel or traverse while raising or lowering the main hoist.

The pendants shall be provided with a lockable on/off switch with appropriate indicator light.

Controls shall be interlocked to prevent dual activation of functions and each shall be clearly marked with its function. Labels that only rely on adhesive to stay in position shall not be acceptable. All motions shall be controlled by non-latching control buttons.

All motion control push buttons shall be of the two stage type. The initial depression of the button shall select the creep speed and full depression of the button shall select fast speed. Control features shall be included to prevent fast speed being selected without first having accelerated the Plant in the slow speed range.

Where applicable, the following minimum controls shall be provided:

a) On/Off switch;
b) Main Hoist Up/Down - Slow/Fast push buttons;
c) Auxiliary Hoist Up/Down - Slow/Fast push buttons;
d) Cross Travelling Left/Right - Slow/Fast push buttons;
e) Long Travel Left/Right - Slow/Fast push buttons;
f) Emergency Stop mushroom head push button; and
g) Floodlights On/Off.

For outdoor cranes, provision shall be made to store the pendant in a lockable weatherproof cabinet on the crane to prevent environmental damage when not in use. Refer Clause 31.4.12.5.

The load cell shall be able to be set so that the hoist motor trips out in the event the hook load exceeds the crane SWL, or exceeds such smaller load as may be desirable for security against instantaneous overload during hoisting.

During crane testing the load cell shall be able to be reset to 130% of SWL (via a key switch located in the crane hoist DB) to allow test loads of 125% SWL to be lifted.

In all cases, the directional orientation of the pendant horizontal motion controls (i.e. upstream / downstream; left / right) in relation to the appropriate crane shall be indicated by colour coding on the front panel of the pendant and on the crane. The colour coding on the crane shall be clearly visible from anywhere within the reach of the pendant and shall clearly contrast with the colour of the element on which it is mounted. Colour coding on the crane structure shall be by means of bolted-on metal plates according to the following colour codes:

a) Upstream: Arctic Blue;
b) Downstream: Brilliant Green;
c) Left (looking in direction of flow): Golden Brown; and
d) Right (looking in direction of flow): Signal Red.

31.4.10 Cabling

The cabling system on the crane shall be neatly routed and enclosed in non-corrodible ducts or cable trays with covers, securely fixed to the crane frame. Brackets, fasteners and cable tie-down straps shall also be of non-corrosive materials. Plastic type cable ties are not acceptable. All cables entering electric motors shall be protected in accordance with IP 65 of SANS 60529:2013, supported and sealed by means of a metal cable gland. The armouring shall be clamped between substantial tapered sections which form an integral part of the gland.

31.4.11 Wiring Code Numbers

Code numbers shall be clearly marked on all electrical cables, cable cores, wiring and terminal blocks inside switchgear panels and field devices, to enable maintenance staff to trace faults easily.

The wiring diagrams to be supplied with the Operation Manual as specified in Section 1 - General shall have the same code numbers marked on them and shall be strictly in accordance with the actual wiring on the crane.

A laminated A3 sized print of the wiring diagram shall be fixed inside the electrical distribution cabinet panel for easy reference.

31.4.12 Controls and Safety Devices

31.4.12.1 General

The isolator switch shall be a quick break change over type to isolate all crane conductors and it shall be possible to lock and switch in the isolated and earthed positions.

The crane structure and metal cases of all electrical Plant, including conduit and trunking shall be effectively earthed. The Contractor shall supply longitudinal and crane bridge conductors for the earthing Plant.

Motion warning devices, both audible (buzzer) and visual (rotating lights) shall be provided and shall operate continuously with either bridge or trolley motion.

31.4.12.2 Brakes

Each motor(s) of each motion shall be provided with an externally adjustable, multiple friction electro-magnetic disk brake, which shall apply automatically when the power is interrupted. The brakes shall be arranged to release only after a time delay to ensure that the load is held by the drive motor before the brakes are released. There shall be no slipping of loads when the drive motor is stopped or the electricity supply fails.

31.4.12.3 Limit Switches

Over-hoisting and over-travelling limit switches shall be provided for all crane motions. All limit switches shall automatically reset allowing an opposite directional movement to be selected to that which activated the limit switch.

All lifting motions shall be equipped with slack rope and overload devices to cut out the hoist, preventing further rotation of the drums should the load jam for any reason while lowering or rising. This limit switch shall act as an upper limit switch and shall also prevent lowering the hook below a predetermined lower position by interrupting the hoist motor control. These over-travel limit switches shall be of the double protection type with automatically self-resetting action.

Creep speed only shall be available after operation of the over-travelling limit switches for long and cross travel motions, which will allow the crane to approach the end stops slowly.

A stack rope detector shall also be installed that detects ropes crossing over on the drum.

Hoists shall also be provided with an overload switch that stops the hoisting operation when the lifted load exceeds the rated working load limit of the hoist.

31.4.12.4 Lighting

At least two adjustable, waterproof floodlights shall be provided under the footwalks, which will enable safe operation at night or when required. These shall be suitably positioned to illuminate the whole area underneath the crane and down the openings to be serviced by the crane as to eliminate shadows. Facilities shall be provided for the easy replacement of lamps for maintenance purposes. Mounting brackets of the floodlights shall be of rigid construction as to avoid shuddering when the crane is in motion.

31.4.12.5 Weather Protection and Safety Guards

The crane shall be weatherproof regardless of whether it is intended for outdoor use or not.

The crane electrical distribution boxes and limit switches shall be weatherproof to IP 65 of SANS 60529:2013 and all moving machinery, including electric motors, shall be guarded to the satisfaction of the designer and Engineer. Guards, however, shall be easily removable for access and maintenance purposes.

Since the cranes will work in a humid atmosphere, all external electrical fittings forming part of the electrical distribution panels shall be protected in accordance with IP 65 of SANS60529:2013. Push buttons shall be covered with rubber hoods. Isolators, switches and instruments mounted on the panel and limit switches shall have the necessary 0-rings or rubber bushes for protection against a moist atmosphere. A space heater shall also be provided in the panel cabinet.

The crane shall be furnished with a weatherproof 3CR12 cabinet in which to store the operating pendant when the crane is not in use.

31.4.12.6 Lightning Surge Protection

All electronic and other Plant prone to lightning surge damage shall be protected in accordance with the guidelines detailed in the CSIR report No*. Elek - 165 – "a lightning protection guide for electronic installation".*

All power and signal circuits shall be designed to separately cope with 65 kA, 5 kV, 1/50 microsecond pulses (0.5 joule), repeated 20 times per burst of pulses in a short period of time (of the order of 20 seconds).

Earth connection for lightning protection Plant shall have a minimum conductor section of 70 mm^2. A direct earth connection cable route to the building earth shall be provided.

31.5 CORROSION PROTECTION

All Plant supplied under this section shall conform to Section 37 - Painting and Corrosion Protection and Section 28 – Mechanical General.

The crane hoist units shall be completely weatherproof under all weather conditions applicable to the Site and the steelwork designed and detailed so as to obviate the possibility of rainwater entrapment prejudicing the life of the corrosion protection system employed. All control devices, pendants and electrical junction boxes shall be protected from the environment.

31.6 MATERIALS

See Sections 28 and 38 - Mechanical General and Electrical General respectively.

The following materials shall be used for the manufacture of hoist structures:

a) Indoor and outdoor crane structures: coated mild steel; and
b) Indoor and outdoor crawl beams: mild steel.

31.7 INSPECTION AND QUALITY CONTROL

Inspection and quality control shall be in accordance with Sections 28 and 38 for Mechanical General and Electrical General respectively.

31.8 OPERATION AND MAINTENANCE (O&M) MANUALS

Submission of O&M Manuals shall be as required in Section 48.

31.9 FACTORY ACCEPTANCE TEST (FAT)

Testing the crane shall be strictly in accordance with SANS 4310:2002.

The crane shall be completely assembled for functional tests and inspection at the manufacturer’s works.

Full mechanical (including welding preparation and welding) and corrosion protection inspection of the items shall be carried out at the manufacturer's works. Workmanship and dimensional correctness shall be checked prior to corrosion protection procedures.

Preference is given to the load test being carried out in the manufacturer’s works by his staff and with the test load he provides. If the Contractor, however, wishes to perform the load test at Site, then he/she shall be responsible for providing the test load (Working load + 25% overload) and arranging for such tests to be witnessed by the Engineer.

The following tests are required:

i) All crane motions shall be tested under loads of 100% and 125% of the rated capacity for each hoist on the crane, and the crane must be able to safely handle the load equal to 125% of the rated capacity;
ii) All limit-switches, brakes and other protective devices shall be tested when the crane is carrying 100% of the rated capacity;
iii) Structural deflections shall be measured accurately with loads of 100% and 125% of the rated capacity and shall not exceed the allowable deflections specified under Clause 31.3.8;
iv) The load shall be travelled over the full length of the bridge and trolley runways during the 100% and 125% load tests; and
v) During crane testing the load cell shall be able to be reset to 130% of SWL (via key switch located in the crane hoist DB) to allow test loads of 125% SWL to be lifted.

The manufacturer shall provide a certificate of examination and test that shall be signed by the designer as well as the Engineer or his/her representative who witnessed the test.

The electrical installation of the completely assembled and installed crane shall be tested at Site for compliance to SANS 10142.

31.10 STORAGE, HANDLING AND TRANSPORT

Storage, handling and transport of Plant shall be in accordance with Sections 28 and 38 for Mechanical General and Electrical General respectively.

31.11 INSTALLATION AND PRE-COMMISSIONING

The Contractor shall be responsible for the installation of all Plant supplied in terms of this Section as well as for adjustments to ensure proper functioning of the complete unit as part of the pre-commissioning process.

The Contractor is allowed to commission and use the crane during construction under certain conditions as stipulated in Section 48 – Tests on Completion. The final Tests on Completion shall be done in terms of Section 48 of the Specification.

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT № TCTA 021-001

TCTA MODULAR STANDARDS

SECTION 32

PIPES AND PIPE SPECIALS

TCTA MODULAR STANDARDS
SECTION 32
PIPES AND PIPE SPECIALS

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SECTION 32
PIPES AND PIPE SPECIALS

32.1 SCOPE, DEFINITIONS AND REFERENCES

32.1.1 Scope

This Section deals with the design, manufacture and supply of steel pipes, pipe specials and pipe ancillaries to be installed above ground, within buildings, concrete structures (pump stations, etc.) and chambers and underground.

The scope shall include, but not limited to, the following:

a) Design of pipes, pipe specials (reducers, tees, bends, bifurcations etc.), pipe ancillaries (flanges, nozzles, pipe reinforcement, sliding, pipe supports, anchorages, etc.);
b) Manufacturing, delivery to Site and storage, including flange jointing materials etc;
c) Factory corrosion protection;
d) Corrosion protection on Site of field welds and repairs;
e) Testing in the factory and on Site;
f) Maintenance during the Defects Notification Period; and
g) Preparation of an Operating & Maintenance Manual.

This Section shall be read in conjunction with:

- Section 33 – Laying and Testing Steel pipes;
- Section 28 – Mechanical General;
- Section 37 – Painting and Corrosion Protection;
- Section 30 – Pumps and Ancillary Equipment;
- Section 34 – AC Mitigation and Cathodic Protection;
- Section 35 – Valves and Section 41; and
- Control and Instrumentation - Plant and Installation.

32.1.2 Definitions

Except as indicated below the definitions given in SANS 10044 and SANS 719 shall apply:

a) **"Approved Inspection Authority"** (AIA) shall mean the organisation appointed to independently monitor and test the quality of Plant, material, welding, corrosion protection and other aspects of the Works identified by the Engineer, during manufacturing, delivery to Site, installation and testing, on behalf of the Employer and the Engineer.

b) **"Cut-and-shut bend"** means a bend formed by cutting out one or more V-shaped sections equally disposed about a line at right angles to the axis of the pipe, preparing the cut-out edges for welding; bending the pipe to form the bend and welding the pipe shut along the prepared edges to complete the bend.

c) **"Exact length"** as defined in SANS 719 shall be the standard pipe length stated in Clause 32.2.8.

d) **"Pipe"** means a straight cylinder of uniform diameter and of standard or non-standard length and having square-cut (plain or prepared) ends.

e) **"Specials"** means any pipe other than a pipe as defined above, including bends, tees, crosses, angle branches, reducers, tapers, couplings flanged pipes etc.

32.1.3 Abbreviations

AIA	Approved Inspection Authority
API	American Petroleum Industry
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWWA	American Water Works Association
BS	British Standard
BS EN	British Standard and European Norm
BSPT	British Standard pipe thread
D	Diameter
DN	Nominal diameter – (ISO 6708)
ERW	Electrical resistance weld
FA	Flange adaptor
FBE	Flanged both ends
FOE	Flanged one end
FW	Field weld
ID	Inside diameter
ISO	International Standards Organisation
OD	Outside diameter
PBE	Plain both ends
PE	Plain end
PN	Nominal pressure (Rating) - (ISO 7268)
PQI	Production Quality Inspectorate
RFA	Restrained flange adaptor
SANS	South African National Standard
SAW	Submerged arc weld
SOC	Slip-on coupling
STT	Surface Tension Transfer
t	Wall thickness of pipes
WP (B)	Weld preparation (Butt)

32.1.4 References

When reference is made to a published national or international Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a published national or international Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise by the Engineer.

The Contractor shall comply with General Safety Regulation 9 when welding, cutting and similar operations.

32.2 GENERAL REQUIREMENTS

32.2.1 Supporting Specifications

The following specifications shall apply to the manufacture of pipes and specials using either submerged arc spiral welding or longitudinally welded "cans" rolled from low carbon or steel plate and joined by submerged arc circumferential welding to form suitable pipe lengths:

SANS 62-1&62-2	Steel pipes and pipe fittings up to 150 mm nominal bore, Part 1 and Part 2
SANS 719	Electric welded low carbon steel pipes for aqueous fluids (large bore)
SANS 1431	Weldable structural steels
SANS 1476	Fabricated flanged steel pipework
SANS 1700	Fasteners
SANS 4633	Rubber seals – Joint rings for water supply, drainage and sewerage pipelines
SANS 15589-1	Cathodic protection of pipeline transportation systems – Part 1
BS 534 (see note 1)	Steel pipes and specials for water and sewage
BS 970 (see note 2)	Wrought steel for mechanical and allied engineering purposes
BS EN 1092	Flanges and their joints
BS 7531	Rubber bonded fibre jointing for industrial and aerospace purposes
API 5L	Line pipe
API 1104	Welding of pipelines and related facilities
AWWA M11	Steel pipe - a guide for design and installation
AWWA C208	Dimensions for fabricated steel water pipe fittings
ISO 7005	Metallic flanges
ISO 8501-1	Preparation of steel substrate before application of paints and related products. Visual assessment of surface cleanliness – Part 1
ASME BPVC	ASME Boiler and Pressure Vessel Code Section VIII
BS PD 5500	Specification for Unfired Pressure Vessels
BS EN 13445-3	BSI British Standards Unfired Pressure Vessels

ASME B31G Manual for Determining the Remaining Strength of Corroded Pipelines

Note 1 - Replaced by BS EN 10224 (Non-alloy steel tubes and fittings for the conveyance of aqueous liquids including water for human consumption) and BS EN 10311 (Joints for the connection of steel tubes and fittings for the conveyance of water and other aqueous liquids), but for the purpose of this Contract the previous version remains applicable.

Note 2 – BS 970 Part 1: 1991 & BS 970 Part 3: 1991 replaced by BS EN 10088-3 covering chemical composition & mechanical properties.

32.2.2 Welding of Specials

Welding of specials and weld inspection shall conform to the requirements of API Standard 1104 – Welding of Pipelines and Related Facilities.

All butt welds and fillet welds on specials shall have an internal weld where practical. The weld bead of the internal weld shall not extend above the prolongation of the original inside surface of the pipe by more than 2 mm. Internal reinforcement in the form of backing rings at weld seams shall not be permitted.

Reducer pieces shall not have more than two longitudinal weld seams.

32.2.3 Qualification of Welders

All manual or semi-automatic welds and repair welds shall only be undertaken by welders qualified in terms of tests laid down in the latest issue of the API Standard 1104 – Welding of Pipelines and Related Facilities.

32.2.4 Non-destructive Tests and Adjudication

Radiographic testing of welds shall be used unless approved otherwise by the Engineer. Where welds cannot be tested using radiographic methods, a combination of alternative methods shall be submitted for approval by the Engineer.

The following standard specifications shall apply:

Radiographic Inspection:	API 1104
Ultrasonic Inspection:	API 5L
Dye/Liquid Penetrating Test:	API 1104 and SANS 1200L
Magnetic Particle Inspection:	ASME Boiler and Pressure Vessel Code, Section V,

The results of the radiographic testing shall be saved in digital format for archiving of the records.

32.2.5 Outside Diameters and Minimum Wall Thickness

The design stress for pipes and pipe specials at the specified design pressures shall not exceed the following values:

- For working pressure: 50% of the minimum yield stress of the steel;
- For surge pressure: 60% of the minimum yield stress of the steel; and
- For field test pressure: 75% of the minimum yield stress of the steel.

The minimum pipe wall thickness to prevent buckling and excessive deflection of straight pipes due to internal sub-atmospheric pressures and external loads shall not be less than the larger of 4 mm or determined by the following method:

- 1/150 x pipe outside diameter for buried pipes; and
- 1/130 x pipe outside diameter for exposed pipes.

Deflection (ovality) of buried pipes and specials shall not exceed:

- 2% for cement mortar lining;
- 3% for all other pipes.

Refer to Section 33 for the definition of deflection (ovality).

For nominal diameter pipes of 150 mm and below the provisions of SANS 62 for plain ended, heavy class pipe shall apply.

All minimum wall thicknesses as specified shall mean absolute minimum thickness. No negative tolerances shall be allowed on these thicknesses.

When Surface Tension Transfer (STT) welding is used for field welding on joints, the minimum pipe wall thickness should not be less than 6 mm.

32.2.6 Dimensional Requirements of Pipes

The tolerances on all dimensions excluding pipe diameter shall be in accordance with SANS 719: 2011 Clause 5.1 inclusive of the following:

- The tolerance applicable to the outside diameters (OD) of pipe ends above 1 250 mm shall be between +2.4 mm and 1.0 mm over a length of 150 mm (Refer Table 3 of SANS 719:2011).
- The tolerance applicable for pipe outside diameters (OD) above 1 250 mm, the tolerance shall be 6 mm. (Refer Table 4 of SANS 719:2011). – Refer to note1 below.

Notes:

1. Where the Contractor plans cutting mitre joints, the OD tolerances shall be specifically checked for compatibility when setting up these field joints. Refer to maximum offset requirements specified in Section 33.

2. Line pipes shall be of fixed standard length between 9 m and 19.5 m except where shorter lengths are specified.

3. The tolerances on the squareness of the pipe ends for pipes larger than 500mm OD is described by subclause 5.1.5 b) of SANS 719:2011. The Contractor can instruct reduced / tighter pipe manufacturing tolerances where and when required to suit the planned field weld setting up requirements. The measurement method shall be subject to approval by the AIA or the Engineer.

For nominal diameter pipes of 150 mm and below the provisions of SANS 62 for plain ended, heavy class pipe shall apply.

32.2.7 Specials

32.2.7.1 General

The Contractor shall submit his design calculations and drawings to the Engineer for review before manufacture commences. Designs shall be in accordance with AWWA M11, BS PD5500 or BS EN 13445-3 as may be applicable.

Specials shall be manufactured from pipe conforming to this Section.

For bifurcations and branch connections the plate thickness of the barrel and branch shall be such that the maximum stress shall not be greater than that for an uncut pipe of the theoretical required minimum thickness. However, where it is more economical to provide external welded reinforcement (collar, wrapper and crotch plates, etc.) these forms of reinforcement shall be used to achieve the same results.

Lifting eyes (lugs) shall be welded to all unwieldy specials and to all specials of DN500 and larger to facilitate handling and minimize damage to the protective coating during handling.

All specials and fittings shall be manufactured exclusively at the factory of the manufacturer. No site fabrication or repair of specials other than mitre bends of 11.25^{o} or less will be permitted unless the Contractor’s workshops, equipment, facilities, staff, quality control facilities etc. is approved by the Engineer for each specific portion of the manufacturing process and subject to the condition that it is maintained by the Contractor to the satisfaction of the Engineer. The Engineer shall retain the right to withdraw his approval at any time.

32.2.7.2 Bends

The dimensions for bends shall be in accordance with AWWA C208. Bends shall either be smooth formed or gusseted. The maximum angle between oblique butt-ends of segments for gusseted bends including bends on sweep-T items shall not exceed 22.5° in accordance with the AWWA C208. “Cut-and-shut” bends will not be permitted. Bends shall have their “centre plane” marked with two small punch marks close to both ends of the bends to facilitate correct positioning of the bends during laying.

Bend radii shall be 2 times OD unless otherwise indicated on the drawings.

The number of segments that a gusseted bend shall comprise shall be as given below, unless otherwise indicated on the drawings:

- Bends 11.25° to 22.5° 3 segments
- Bends above 22.5° to 45.0° 5 segments
- Bends above 45.0° to 90.0° 7 segments

Mitres for bends (links) of 11.25° and less shall be made in the field as part of the pipe laying operation in terms of Section 33 – Laying and Testing Steel Pipes.

32.2.7.3 Branches and Nozzles for Bypasses, Drains, Air Valves, Pressure Gauges, etc.

Branch connections shall have barrel and branch plate thicknesses such that the maximum stress shall not be greater than that for an uncut pipe of the theoretically required minimum thickness. However, where it is more economical to provide external reinforcement in the form of collar or wrapper or crotch plates, these forms of reinforcement shall be used to achieve the same results.

Reinforcement to pipe branches shall be by full penetration welding. Branch connections shall be as remote as possible from the seam or spiral weld on the barrel.

Branches to pipes or pipe specials shall be of minimum DN150 to allow continuity of corrosion protection within the pipe and shall be flanged and of “stub-in” type in accordance with ANSI B31.3, welded internally and externally.

At scours and pipeline access points, 25 mm stainless steel grade 316 L diameter nozzles shall be provided on a DN 150 flanged pipe on a blank flange. Such nozzles shall be threaded to BSPT and designed for the maximum possible pressure in the pipeline.

Centre lines of nozzles and branches shall be at right angles to the barrel of the pipe.

Branch connections shall be as remote as possible from the seam weld on the barrel and shall generally be placed as follows:

f) For air valve tees the centre lines of the air valve branch and the barrel shall intersect at right angles or vertically, depending on the type of tee specified. The branch shall be flanged and have a nominal diameter of:
   - 700 mm for pipelines of DN700 and larger; or
   - Equal to the DN of the main pipe for pipelines of DN smaller than 700 mm.

g) For scour valve tees the branch invert shall be located on the pipe invert and point horizontally at right angles to the barrel of the pipeline. The branch flange shall be set so that the scour valve spindle points vertically upwards.

32.2.7.4 Reducer Pieces

The tapered portion of a reducer shall be at least four times the length of the tapering difference in diameter unless otherwise approved by the designer. Tapered sections shall also have a maximum angle of divergence of:

- 7° for concentric reducers
- 14° for eccentric reducers

Tapers shall be concentric unless otherwise indicated on the drawings. The impact of the use of eccentric reducers upstream of the final selected pumping systems shall be verified during the design. The design of the reducers shall comply with the requirements of AWWA M11 and AWWA C208.

32.2.8 Flanges and Gaskets

Refer to Section 28 - Mechanical General in this regard.

32.2.9 Pipeline Access

Access points to pipelines shall be provided at all air valve and scour valve installations. The access opening shall have flanged covers to facilitate easy removal and re-installation and have a nominal diameter of 700 mm for pipelines of DN700 and larger or equal to the DN of the main pipe for pipelines of DN smaller than 700 mm.

Unless the pipeline is designed for pigging, access points shall be provided every 800600 m.

32.2.10 Flexible Couplings and Flange Adaptors

The type of coupling and flange adaptor shall be subject to the Engineer’s approval and Straub, Arpol or equivalent clamp on couplings are not acceptable.

Flexible couplings shall have a centre register, unless approved otherwise by the Engineer. All couplings and flange adaptors shall permit a repeated movement to cater for thermal expansion and contraction of the pipes, removal of specials and valves and shall further allow for the angular deflections, all in accordance with the manufacturer’s specification for each specific size.

Tolerances during installation relating to gaps, misalignment, angular deflection, differences in pipe OD, axial movement, lateral displacement, etc., shall be comply with the manufacturer's specifications.

32.2.11 Provision of Thermit Welding Pads

Where pipes and specials are to be jointed by means of flexible couplings and will be subjected to cathodic protection, the manufacturer shall weld steel plates not less than 50 x 75 x 10 mm thick 250 mm from each end of all pipes during the pipe manufacturing process (i.e. before lining and coating) to provide adequate area for thermit welding pad bonding cables to the piping to make it electrically continuous and enable a cathodic protection system to be applied without damage to the lining.

32.2.12 Insulating Flanges

Refer to Section 28 - Mechanical General and Section 34 - AC Mitigation and Cathodic Protection in this regard.

32.2.13 Steel Pipe Stiffeners

(a) Welding Requirements

Welding on steel stiffeners shall conform to the general welding specification for pipelines as specified in this Section with the following additional requirements:

- All welds shall be substantially uniform in appearance and shall show full fusion and penetration throughout their lengths;
- The outer weld bead shall not exceed a height of 3 mm. The inner weld bead shall not project more than 2 mm and all excess weld metal shall be removed by grinding to the satisfaction of the Engineer;
- The weld, heat affected zone and surrounding parent metal shall be free from cracks and other defects described in API Specification 5L.

(b) Inspection and Quality Control Requirements

Liquid Penetrant Testing in accordance with Clause 32.10.5 shall be done on completed welds between stiffener ring halves and the full length of completed welds for the circumferential fillet welded seam made to join stiffeners to pipe shells.

Ultrasonic inspection shall be carried out on the full length (100 per cent) of every circumferential fillet welded seam made to join stiffeners to pipe shells.

32.3 MANUFACTURE AND WORKMANSHIP

32.3.1 General

Longitudinal seams, spiral seams and shop girth seams shall all be butt welded.

If it is necessary to reshape pipes after they have been welded, reshaping shall be performed by re-rolling or by pressure. Reshaping of pipes by dropping or hammering will not be permitted. Sizing of pipe ends to achieve specified end tolerances will be permitted. This may include expanding pipe ends either mechanically or hydraulically by a maximum of 1.5% of its original diameter.

32.3.2 Preparation of Pipe and Special Ends

32.3.2.1 Mechanical Couplings and Fillet Welds

Ends for use with mechanical couplings shall be square cut or bevelled plain ends, cut square to the pipe axis, with all edge burrs, weld splatter and scratches removed. The outside of the pipe shall be free of indentations, projections or roll marks for a distance of 250 mm measured perpendicularly from each end to permit proper make-up of the coupling. Longitudinal or spiral welds on the outside of the plain end shall be ground to plate or sheet surface for a minimum distance of 250 mm or 3 X OD whichever is the lesser. Also see Clause **Error! Reference source not found.**.

32.3.2.2 Butt Welds

Pipes and specials which require joints to be butt welded on site shall be supplied with ends bevelled (“WP (B)”).

32.3.2.3 Weld Beads

The internal weld bead resulting from fusion welding and the height of the upset metal and flash on the inner surface resulting from electric resistance welding shall not exceed 2.0 mm. No undercut shall be permissible.

For pipes and specials to be jointed by butt welding, the internal weld bead shall be ground flush with the internal surface of the pipe or special for a length of 200 mm from the ends to be jointed.

For pipes or specials not to be jointed by butt-welding, the external weld reinforcement or upset metal and flash shall be ground flush with the body for a length of 200 mm back from the ends.

32.3.2.4 Spigot and Socket

Spigot and socket ends shall be rolled or fabricated from plate, sheet or special sections to the required shape without hammering. Longitudinal or spiral welds on the inside of the socket and the outside of the spigot shall be ground to plate or sheet surface for a distance not less than the depth of insertion of the spigot into the socket.

32.3.2.5 Bevelling

All bevelling, where required, shall be delayed until after all non-destructive testing has been completed, but may be done after completion of hydrostatic testing.

32.3.2.6 Flanges

Ends to be fitted with flanges shall have the longitudinal or spiral welds ground to plate or sheet surface for a distance from the ends sufficient to accommodate the flange.

32.3.2.7 Repair of Defects

If a pipe fails to pass any of the tests specified in Clause 32.10, it will be rejected but the Engineer may permit repairs or alterations to be made to enable the pipe to pass the test.

Repairs of welded joints will be permitted during the process of manufacture. Where repairs are required the defective weld metal shall be cut out, and the parent metal prepared by grinding and re-welded.

The repair procedure and performance on repairs shall be in accordance with Section 10 of API 5L. Only qualified welders shall be employed. Each repair weld shall be marked with the welder's identifying stamp. When the repair has been made, it shall be tested in accordance with Clause 32.10.

On discovery of defective welds, the Engineer may call for additional radiographic examination until it is shown that the necessary standard is being maintained.

Should a weld repair be required on a pipe subsequent to hydraulic testing, the pipe shall be retested in accordance with Clause 32.10.

Dents shall, where practicable, be jacked out, provided the extent of the dent is less than what is considered allowable in terms of API 5L, Where the extent of the dent exceeds the allowable limit, a window repair shall be done or a section of pipe replaced.

32.3.2.8 Grinding Flush

Where welds are required to be "ground flush" great care shall be taken to avoid over-grinding, thus thinning the pipe wall. Random thickness measurements at "ground flush" locations shall be made to prove that over-grinding has not occurred. In the event that material pipe wall thinning is detected the specified minimum thickness shall be restored by means approved by the Engineer.

32.4 CORROSION PROTECTION

Corrosion protection of pipes and specials shall conform to Section 37 – Painting and Corrosion Protection. Colour coding shall be in accordance with Annexure 37/1 of Section 37 – Painting and Corrosion Protection.

The Contractor shall comply with Construction Regulation 25 - Use of flammable liquids.

32.5 MATERIALS

32.5.1 Pipes and Specials

Unless otherwise indicated on the drawings:

- Pipes, pipe supports and specials of nominal diameter equal to or less than 150 mm shall be manufactured of steel in terms of SANS 62 (heavy class pipes up to 50 bar internal pressure) and API 5L for steel grades up to X52.
- Pipes and specials of nominal diameter larger than 150 mm shall be manufactured from steel grade A, B and C to SANS 719, or steel grade 300WA or 350WA to SANS 1431 or steel grade X42, X46, X52, X56, X60 and X65 to API 5l or EN 10025-2: Steel Grade S355JR + AR, as specified.
- Pipes and specials manufactured from stainless steel shall be grade 316L in accordance with BS 970.
- Pipes and specials manufactured from 3CR12 steel shall be in accordance with EN 10028-7.
- Seamless pipes shall comply with ASTM A106 – Schedule 40(40 bar) or 80(80 bar) as determined by the design pressure.
- Seamless specials and fittings shall comply with ANSI B16.5 & B16.9 – Schedule as determined by the design pressure.

32.5.2 Rubber

Rubber for jointing rings in flexible couplings shall be manufactured from first grade natural rubber to SANS 974 Class F.

32.6 MARKING

Marking shall generally be in accordance with Section 28 - Mechanical General. Additionally, all pipes and specials shall be clearly marked/stencilled alongside a longitudinal or spiral weld on both ends on the inside of the pipe with the following information:

a) Grade and thickness of steel;
b) Serial number of the pipe or special;
c) Nominal diameter (mm);

d) Factory Hydraulic Test Pressure (kPa); and
e) Spool / Coil Number.

The applicable drilling table for each flanged pipe shall be stamped on the periphery of all flanges. Bends shall have their centre plane marked with two small punch marks close to both ends to facilitate correct positioning in laying.

32.7 VALVES

Refer to Section 35 - Valves.

32.8 STORAGE, HANDLING AND TRANSPORT

32.8.1 General

The storage, handling and transportation of Plant shall generally conform to the requirements of Section 28 – Mechanical General.

32.8.2 Storage, Handling and Transport of Pipes and Specials

Pipes and specials shall be protected against damage at all stages from manufacture to installation. Particular care shall be taken to protect the ends of all pipes and specials against denting. Repairable dents shall, where practicable, be jacked out, provided the extent of the dent is less than what is considered allowable in terms of API 5L, Where the extent of the dent exceeds the allowable limit, a window repair shall be done or a section of pipe rejected by the Engineer shall be replaced.

Effective temporary end covers shall be provided for the protection of flanges, prepared ends of plain-ended pipes, specials and fittings, and threads and to prevent damage to the internal lining during transportation and during handling on Site.

Pipeline materials shall be so transported, stored and handled that pipes are not overstressed at any time and specials and fittings are not damaged in any way. All coated pipes shall be handled with particular care and shall be stored on sand bags or similar supports approved by the Engineer to ensure that the pipe coating is not damaged, is at least 150 mm above the ground level at any point and it is not subjected to concentrated pressure from stones or other objects.

The pipes and specials shall at all times be handled with an employing stout, wide canvas or rubber-covered slings and wide padded skids designed to prevent damage to the exterior coating.

The slings for coated pipes shall be at least 500 mm wide for pipes up to DN600, 600 mm wide for pipes of above DN600 and up to DN1200 and 800 mm wide for pipes of DN1400 and larger, or as otherwise approved by the Engineer. Cement-mortar lined steel pipes shall only be lifted by means of spreader beams with at least two slings.

Bare cables, chains, hooks, metal bars, or narrow skids shall not be allowed to come in contact with either the exterior coating or the interior lining of the pipes.

All pipes in excess of 12 m, but not exceeding 19.5 m in length shall be lifted by means of a spreader beam with broad band slings from two points (at about 25% of the pipe length from each end), or as otherwise approved by the Engineer.

Pipe specials requiring mechanical hoisting/lifting shall be provided with suitable lifting lugs to facilitate handling without damaging the corrosion protection. The position and size of the lifting lugs shall be indicated on the workshop drawings.

32.8.3 Transport

Pipes and specials shall only be transported on properly constructed or adapted vehicles containing correctly shaped and padded cradles or with strong, sawdust filled bags separating pipe and vehicle body as well as individual pipes from each other. Special care shall be taken with the transport of all coated steel pipes as damaged coatings might be subject to rejection by the Engineer. Pipes shall be transported and stacked in a manner such as to prevent deformation of the pipe body in excess of 2% of diameter.

Rubber belts with a minimum width of 300 mm and of adequate length shall be used to ensure that the pipes cannot come into contact with each other while being transported or handled. When making deliveries by road transportation, all chains, cables or other equipment used for fastening down the load shall be carefully padded.

Profiled cradles, at least 500 mm wide for pipes up to DN500 and 1000 mm wide for larger pipes, suitably padded for the pipes to rest on, shall be provided on each delivery vehicle. A minimum of two cradles per pipe length shall be used. The padded cradle surface shall be profiled to match the coated outside radius of the pipe and shall support the pipe over an arc length of at least 1000 mm (support angle of 60 degrees).

Suitable means of strapping the pipes onto the delivery vehicle without damaging the coating shall be provided. Where required to prevent unacceptable deflection, the ends of each pipe shall be braced with interior supports or spiders. Stiffened steel pipes shall not be braced.

32.8.4 Loading and Off-loading

Pipes shall never be allowed to be dropped, to fall from trucks or be allowed to collide with each other.

Care shall be taken during off-loading to prevent damage to the corrosion protection system. The pipes shall be placed on supports such as sandbags in a demarcated area which area has been cleared of all vegetation and treated with an effective weed killer. Supports shall be provided at ¼

points along the pipe length. The supports shall be wide enough and so arranged that the bearing area is adequate to prevent damage to the external coating whether due to load intensity or axial thermal expansion movement.

Pads are required between individual pipes where pipes are stacked.

Coated steel pipes shall always be supported on a sufficient number of soft bolsters to prevent damage or the permanent deformation of coatings. Coated steel pipes shall not be stacked more than two pipes high, each layer separated by bolsters.

32.8.5 Material that Deteriorate under the Action of Sunlight

All rubber rings or other materials which will deteriorate under the action of sunlight, ozone or inclement weather, shall be stored in permanent shade in lockable weather-proof sheds.
Pipeline coating that may be subject to deterioration due to sunlight or weather conditions, shall be adequately protected, and the duration of the exposure should be limited as much as possible.

32.8.6 Records of Materials on Site

The Contractor shall keep and maintain a complete and comprehensive record of each pipe, special and fitting delivered to Site. The record shall at least denote the reference number, size, pressure class, location in the pipeline, date, condition at delivery and the location of delivery and the location of storage. Copies of the record shall be submitted to the Engineer at the end of each month or whenever requested by the Engineer.

When pipes, specials and fittings are delivered without reference numbers, it shall be provided by stencilling, labelling or other methods approved by the Engineer.

32.9 INFORMATION AND DRAWINGS TO BE SUBMITTED

32.9.1 Pipe Layout and Shop Drawings

Before issue of shop drawings for manufacture, detailed pipework layout drawings shall be provided for review by the Engineer. Such drawings shall contain general arrangements and assemblies for the pipes, pipe auxiliaries, pipe specials and valves and include materials schedules, standard parts, etc.

Drawings shall be prepared to acceptable industry standards and in accordance with Section 28 – Mechanical General, an example of which shall be submitted for approval by the Engineer before draughting commences. Due account is to be taken in preparing drawings of the necessity, inter alia, to facilitate straight-forward subsequent fit-up on site, without undue site trimming and site preparation for butt welding and minimizing also the necessity for extensive site repairs to internal and external corrosion protection.

32.10 QUALITY ASSURANCE AND FACTORY TESTING

32.10.1 General

Quality assurance and inspections shall be in accordance with Section 28 – Mechanical General.

32.10.2 Workmanship

Workmanship, inspections, inspection documents and repair of defects shall be in accordance with SANS 719, API 5L, Section 10.

32.10.3 Inspection and Methods of Testing

In addition to the requirements of SANS 719, the following requirements shall apply to the testing and inspection of pipes. Specials shall be tested as indicated in the following relevant sections of this clause.

Where possible, specials shall be hydraulically pressure tested in the same way as specified for pipes.

All hydraulic pressure tests on pipes and specials shall be conducted before the application of any corrosion protection.

The Contractor shall provide all necessary testing facilities, labour, instruments, equipment and samples as required by the Engineer or AIA.

The Engineer or AIA shall have the right to select test samples and all instruments utilized for testing purposes shall be subject to the approval by the Engineer or AIA. Instruments shall be calibrated by a body approved by the Engineer.

No mechanical re-working or straining of pipes and specials shall be allowed after testing and inspection.

32.10.4 Non-destructive Inspection

32.10.4.1 Visual Inspection

All finished pipes and specials shall be visually examined and shall be free of injurious defects as defined in API 5L Section 10.2.7. In addition, welds on specials shall be inspected by the application of a penetrant-dye on the inside of the welds and no trace of the dye should appear on the outside of the pipe after completion of the test.

32.10.4.2 Ultrasonic Inspection

The Engineer's review of a detailed method statement is required for the use of this test method prior to the start of production. When this method is used', 100% of all longitudinal or spiral welds on straight pipes shall be checked with an ultrasonic method capable of continuous and uninterrupted inspection of the weld seam in accordance with API 5L, Annexure E5. The equipment shall be checked with an applicable reference standard at least twice every production shift.

32.10.4.3 Radiographic Inspection

100% of longitudinal, circumferential, spiral welds and scalp welds shall be subject to radiographic inspection in accordance with API 1104, Section 9.3. Test records are required to be saved in digital format.

(a) Longitudinal Welded Pipe

Submerged-arc fusion welded pipe, if inspected full length by ultrasonic methods, shall also be inspected by radiographic methods for a distance of 200 mm from each end of each length of pipe. Electric resistance welded pipes shall only be inspected full length by ultra-sonic methods.

(b) Spiral Welded Pipework

Submerged-arc fusion welded pipe, if also inspected full length by ultrasonic methods, shall also be inspected by radiographic methods for a distance of 100 mm from each end of each length of pipe and of the complete "H" at all skelp end welds including 150 mm of the spiral welds in both directions away from the intersection points with the skelp end welds.

(c) Circumferential Butt Welds

100% of the length of all circumferential butt welds shall be examined by radiographic methods.

(d) Specials

100% of all manual or semi-automatic welds in specials (where possible) shall be examined by radiographic methods and all other welds by liquid penetrant testing.

(e) Welding Repairs

For straight piping, 100% of the total length of all repairs shall be examined by radiographic methods.

For pipe specials, 100% of all repairs shall be examined radiographically (where possible) and all other welds by liquid penetrant testing.

(f) Welding of pipes at Rail, Road and River Crossings

For rail, road, river and stream crossings, 100% of the total length of all welds shall be examined radiographically.

32.10.5 Liquid Penetrant Testing

Liquid penetrant testing should be done in accordance with Sub-clause 7.2.1 of SANS 1200 L, clause 9.5 API 1104, ISO 10893-4 and ASTM E165.

32.10.6 Magnetic Particle Testing

Where requested by the Engineer or AIA, magnetic particle testing shall be done in accordance with ASME Boiler and Pressure Vessel Code, Section V, Article 7.

32.10.7 Destructive Testing

The Engineer may require that any pipe be tested to destruction in accordance with SANS 719.

32.10.8 Roundness

Upon completion of the hydrostatic test of individual pipes, the ends of pipes and specials shall be tested by means of “Go / No-go” gauges to check whether flaring or cupping has occurred. If necessary the ends shall be expanded or ground until they comply with the specification. (See also Clause **Error! Reference source not found.**).

32.10.9 Sampling and Compliance with the Specification

This shall be performed in accordance with Clause 6 of SANS 719.

32.10.10 Repair of Injurious Defects

Injurious defects found by non-destructive testing of welds, visual examination, hydrostatic testing or determined by any other means to exceed the limitations in API 5L Section 10 shall be repaired in accordance with API 5L Annexure D but subject in all respects to the requirements of this Section 32.

32.10.11 Inspectorates

The AIA shall have access to all testing facilities and records of the Contractor.

The Contractor shall set up and maintain a welding and corrosion protection quality management and supervision capacity that is aligned with the planned production rates. This Contractor’s production quality inspectorate (PQI) shall be responsible for all routine and production testing and inspections and the recording of such on Site as well as in the factories. Refer to Section 1: General in this regard.

32.10.12 Marking Procedure

All weld lengths to be radiographed shall be clearly marked by the PQI using his identification symbol. This symbol shall appear on the respective radiograph. The radiographed weld and symbol shall not be obliterated by finishing processes until the PQI has accepted the respective weld.

32.10.13 Hydrostatic Testing

When all aspects of fabrication have been completed, but before being cleaned, lined or coated all straight pipes and specials shall be subjected to hydrostatic testing in accordance with SANS 719, Sub-clause 7.3 to a test pressure determined by the formula:

$$P = \frac{1800.f.t}{D}$$

Where P is the test pressure in kPa, D is the outside diameter of the pipe in mm, f is the guaranteed minimum yield strength in MPa for the steel plate and t is nominal wall thickness in mm. This test pressure will produce a circumferential stress in the steel of 90% of the minimum yield stress of the steel. The Contractor shall ensure that secondary stress in the pipe wall due to the test method does not cause the stress to exceed 90% of the yield strength.

The pressure shall be applied gradually and maintained without variation sufficiently long for proof and inspection. While under test pressure the pipe shall be struck smartly and repeatedly along its length with a hammer of a mass of not less than 1 kg.

Should water sweat or ooze from any part or any defects of any nature be discovered the pipe shall be emptied and the defects repaired in accordance with Clause 32.3.2.7 The pipe shall then be retested. Should a pipe, after repair, fail to pass the second hydraulic test the Engineer may reject it.