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11 E&M WORKS (STATION)

11.1 General

11.1.1 The design, coordination, supply, installation, testing and commissioning of all Electrical and Mechanical (E&M) Works shall form part of the scope of work under this Contract.

11.1.2 The Electrical Works involves design, coordination, supply, installation, testing and commissioning of touch voltage protection, earthing system, equipotential bonding and stray current corrosion control for Maju station and tunnels as detailed and described in the LTA Civil Design Criteria for Road & Rail Transit Systems, Materials & Workmanship Specification for Civil & Structural Works and Civil Defence Shelter Requirements for MRT stations.

11.1.3 The Mechanical Works involves design, coordination, supply, installation, testing and commissioning of water services, fire Hydrant System, Sewerage & Sanitary System, Station & Tunnel Drainage Sump Pumping System for Maju station and tunnels as detailed and described in the LTA Civil Design Criteria for Road & Rail Transit Systems, Materials & Workmanship Specification for Civil & Structural Works and CD Shelter Requirements for MRT stations.

11.2 Touch Voltage Protection

11.2.1 The Contractor shall provide platform touch voltage protection in accordance to the Specifications and design requirement as specified in **Chapter 13** of the LTA Civil Design Criteria for Road & Rail Transit Systems and **Chapter 25** of the Materials & Workmanship Specification for Civil & Structural Works.

11.2.2 There shall be no fire rated end return door within the touch voltage protection zone.

11.2.3 General Requirements

11.2.3.1 At the edge of platform in the station, the Platform Screen Doors (PSD) separate the passengers from the tracks. The PSD's shall be connected to earth through the rails so that they are connected to a separate earth from the station, but the same earth as the electric trains.

- 11.2.3.2 Should there be an electrical fault and the train bodies or doors be connected to the electric operating system, passengers alighting from the train and touching the PSD would not form a separate circuit. However, if these passengers were able to touch parts of the station structure or finishes that were connected to the earth of the station, they would complete a circuit with the PSD or Train and could suffer from electric shocks. These electric shocks are termed touch voltage. The Contractor shall provide an effective system to insulate the finishes and structures within the protected zone, including floors, walls and columns. The finishes and structures shall be electrically isolated from earth, or provided with a suitable isolation coating, to avoid harmful touch potentials.

11.3 Earthing System

11.3.1 General Requirements

- 11.3.1.1 The reference design for the Earthing System is indicated in the Authority's Drawings. The Contractor shall design, supply, install and test the earthing system in accordance with SS 638, SS551 and ANSI/IEEE standards. All design reports shall be endorsed by the Contractor's Registered Electrical Professional Engineer (PE).
- 11.3.1.2 The Contractor shall interface with the associated System-Wide Contractors (SWC) for the works described under **Clauses 11.3.2 and 11.3.3** below.
- 11.3.1.3 The design detailed in **Clause 11.3.2** is the minimum requirements of the earth mat(s)/earth electrode pits. Any deviations after the actual soil measurement during construction shall be submitted for Engineer's acceptance, unless otherwise specified.
- 11.3.1.4 The Contractor shall engage a Registered Electrical Professional Engineer (PE) to carry out individual soil resistivity test at each end of the earth mat locations stipulated for the station within six (6) months after Contract award. The Contractor shall carry out individual soil resistivity test at each earth mat areas prior to construction of the station base slab.

- 11.3.1.5 The soil resistivity test shall use the Wenner 4-pin method and the results to be submitted by the Contractor shall be endorsed by a Registered Electrical Professional Engineer (PE). The Contractor shall select a minimum of four (4) test locations for the earth mat subject to the acceptance of the Engineer. Five (5) sets of tests shall be conducted at each location; each set at pin spacing of 2m, 4m, 6m, 8m and 10m respectively. The Contractor shall submit the results and design verification to the Engineer for his acceptance.
- 11.3.1.6 In the event that the measured soil resistivity is found to be higher than the assumed value indicated in the Authority's Drawing, the Contractor shall develop his design to comply with the passing criteria for earthing resistance of not more than 1Ω. The Contractor shall submit detailed proposals endorsed by Contractor's PE/Licensed Electrical Worker (LEW) to the Engineer for acceptance. The cost and time implications arising from developing the design including additional soil replacement, supply, delivery, and all installation works shall be deemed included in the Contract Price;
- 11.3.1.7 The Contractor shall prepare the necessary detailed working drawings and test procedures endorsed by the Contractor's PE/LEW and submit to the Engineer for approval. The earth mats, earth electrode pits, earth risers and earth inspection pits shall be provided by the Contractor.
- 11.3.1.8 If the Contractor is not able to achieve earthing resistance of less than 1Ω after the installation of the earth mat system, the Contractor shall carry out the necessary remedial works to achieve the required earthing resistance. The Contractor shall propose the necessary remedial works and submit to the Engineer for acceptance. All the necessary remedial works to be carried out by the Contractor shall be deemed included in this Contract.
- 11.3.2 Installation and Execution by the Contractor
 - 11.3.2.1 Earth Electrode Pit Systems shall be provided at ground level, in compliance with SS 551:2009 requirements.
 - 11.3.2.2 Earth Mat Systems shall provide coverage for the entire station box and be installed underneath the station box. As a minimum requirement, the earth mat shall comprise a network of earth rods and bare copper tapes laid 300mm below the under-platform slab / ground level. The interval of two (2) earth electrodes shall be not more than 7.2m. Connections between earth rods and bare copper tapes shall be by exothermic welding (or equivalent) and must be inspected by the Engineer before backfilling.

- 11.3.2.3 The Contractor shall conduct a soil replacement of appropriate depth, or any other method subjected to the Engineer's approval, to achieve a maximum soil resistivity of 300 ohm-m.

- 11.3.2.4 As a minimum requirement, the 185mm² bare stranded copper conductor shall be laid and buried in soil to form earth mat as indicated in the Authority's Drawing with exothermic welding (or equivalent) connection between junction of conductors. Ground rods shall be 16mm diameter 3600mm long copper steel earth rods located in the bored holes (300mm diameter, 3600mm depth) backfilled with ground enhancement material with the diameter and depth as indicated in the Authority's Drawings. The ground enhancement material with resistivity not more than that marconite compound resistivity shall be used to improve the soil resistivity. Connections between earth rods and bare copper conductor shall be by exothermic welding (or equivalent) and shall be inspected by the Engineer before backfilling.

- 11.3.2.5 The earth mat shall be connected to the earthing closet / risers by 185mm² low smoke zero halogen insulated copper cable clamped onto the electrode of the watertight earth inspection chamber. The insulated cable shall be enclosed in a 50mm diameter ABS pipe concealed within the under-platform slab to the equipment rooms as indicated in the Authority's Drawing.

- 11.3.2.6 The earth mat shall be provided with a testing facility comprising of one (1) test pit / probe connected to the earth mat and two (2) more stand-alone test pits for current and voltage probes. Each pit / probe shall be provided with 95mm² low smoke zero halogen insulated copper cable leads terminated inside the earthing closet. The earth mat test point terminated in the closet shall also be extended to the earthing closet located at grade as indicated in the Authority's Drawing.

- 11.3.2.7 At each riser cable entry through the base slab/ floor slab/ wall of the riser a tinned copper water-stop sleeve shall be provided to prevent the ingress of water or fire breaking through. The sleeve shall be coated with epoxy resin and be provided with all round hydrophilic or equivalent water stop.

- 11.3.2.8 The Contractor shall coordinate with SWC (Electrical Services) and other SWCs for termination of the earth riser cables onto the main earth bars.

- 11.3.2.9 The copper conductors at the earth inspection chamber at ground level shall have a label "Electrical Earth - Do Not Remove".

- 11.3.2.10 All underground cables crossing driveways or hardcore areas shall be provided with heavy duty UPVC pipes fully encased in concrete with full haunching.
- 11.3.3 Testing
- 11.3.3.1 All test equipment shall be calibrated by an accredited test laboratory and the calibration shall be valid at the time of testing
- 11.3.3.2 The Contractor shall carry out the following earthing mat tests:
- (a) Individual earthing mat test;
 - (b) Continuity test after earth risers are terminated on earth bars; and
 - (c) Final earthing resistance test.
- 11.3.3.3 The test method statements shall be submitted to the Engineer for approval prior to carrying out of the test. All test method statement and reports shall be endorsed by the Registered Electrical PE. The Contractor shall invite all relevant SWC, Authority's In-house Designers and their Professional Engineer to jointly witness the testing.
- 11.3.3.4 Two (2) weeks prior to the commissioning of the 22kV/415V power supplies (Power On Date specified in Appendix B of the Particular Specification), the Contractor's Electrical PE shall carry out a final earthing resistance test. It is essential that all inspection chambers be properly completed before the final earth test.
- 11.3.3.5 The Contractor's Electrical PE shall submit six (6) original copies of endorsed earthing certificate (Declaration of the Earthing System), test report/ results and As-built Drawings to the Engineer prior to the commissioning of station power supplies.
- 11.3.3.6 The Contractor shall provide labels next to the earth bars indicating the test dates, test conditions and test results of the earthing resistance.
- 11.4 Stray Current Corrosion Control**
- 11.4.1 General Requirements
- 11.4.1.1 The provision of Stray Current Corrosion Control shall meet the following objectives:
- (a) To ensure a 120-year design life for railway structures; and

- (b) To provide facilities to monitor and mitigate the stray current effects on the structures.
- 11.4.1.2 The Contractor shall employ a specialist contractor for the design, supply, delivery and installation, testing and commissioning of zinc reference electrode, termination boxes and associated cables and accessories; and
- 11.4.1.3 The Contractor shall evaluate the requirements for Stray Current Corrosion Control within his design, coordinate with all relevant interface details with all necessary parties and produce working drawings for the approval of the Engineer.
- 11.4.1.4 The Contractor shall provide Stray Current Corrosion Control in accordance to the Specifications and design requirement as specified in Civil Design Criteria for Roads & Rail Transit Systems and Materials & Workmanship Specification for Civil & Structural Works.
- 11.4.2 Reference Electrodes
 - 11.4.2.1 Reference electrodes to be provided by the Contractor.
 - 11.4.2.2 Reference electrode shall be made of high purity zinc of 99.90%, with minimum weight of 350 grams, pre-packaged in a special backfill, and provided with a reference electrode wiring cable to reach the reference cell termination box without intermediate joints. The Contractor shall demonstrate the zinc reference electrode has a life span of more than 25 years under short-circuit condition.
 - 11.4.2.3 Each electrode terminal shall be covered by a suitable terminal box for protection. The terminal box shall be of stainless steel material and of IP65 construction with removable box cover.
 - 11.4.2.4 Reference electrode wiring shall have an insulation level of 1.8/3kV and be single core, multi-stranded copper conductor and XLPE insulated.
- 11.4.3 Testing and Commissioning
 - 11.4.3.1 The types, methods, procedures of the tests and measurements shall be submitted to the Engineer for approval prior to conducting the tests. All test instruments and measurement charts are to be provided by the commissioning party.
 - 11.4.3.2 Upon completion of a commissioning test, a test inspection certificate endorsed by the Contractor's PE shall be submitted for the Engineer's acceptance.

11.5 Equipotential Bonding (EPB)

11.5.1 General Requirements

- (a) The Singapore Standard for electrical systems (SS 638) requires all metallic components in the station and tunnel that could be subject to connection to electrical current to be separately bonded to the common earth. This earth bonding is known as equipotential bonding (EPB); and
- (b) The Contractor and all SWC are required to comply with the SS 638.

11.5.2 The Contractor shall provide EPB in accordance to the Specifications and design requirement as specified in the Authority's Drawings, SS 638, SS551 and the LTA Civil Design Criteria for Roads & Rail Transit Systems.

11.5.3 All metallic components in the station and tunnel are to be connected to the station earth in accordance with SS 638. **Table 1** in **Chapter 13** of the LTA Civil Design Criteria for Roads & Rail Transit Systems gives particular requirements relating to the station components.

11.5.4 The basis for the scope of work of EPB provision is that whoever provides the said equipment or services shall also be responsible for providing the EPB, which shall include the design submission, endorsement and the submission of As-built Drawings.

11.5.5 Where EPB provisions are identified to be required in **Table 1** of **Chapter 13** of the LTA Civil Design Criteria for Roads & Rail Transit Systems, the Contractor shall provide the supplementary bonding to the nearest EPB conductor. The Contractor shall engage an Electrical PE for the certification of the complete EPB system.

11.6 E&M Equipment Delivery Routes

11.6.1 The Contractor shall design, supply and install the lifting facilities in accordance to the Specifications and design requirement as specified in Chapter 13 of Civil Design Criteria for Roads & Rail Transit Systems.

- 11.6.2 It is envisaged that during construction stage, some equipment and MEP Modular Units will be lowered from ground level to concourse and platform level via the temporary opening, vent shafts or delivered via the tunnels, the Contractor shall ensure proper lifting facilities will be provided above the temporary opening for equipment delivery as required. The Contractor shall coordinate with interfacing parties and confirm the required lifting (above the temporary opening) capacity. The Contractor shall agree and co-ordinate the delivery routes of the E&M equipment and MEP Modular Units with the interfacing parties and ensure that obstructions are either removed or avoided before the delivery. For future replacement of E&M equipment, the Contractor shall ensure that the floor access hatches with lifting beams above the platform, back-of-house common areas or within the off-track plant room area shall be provided as required.
- 11.6.3 The Contractor shall coordinate with the interfacing parties to ensure that the designated routes are adequate for the delivery and future replacement of the E&M equipment in the station and tunnels. The Contractor shall coordinate the delivery route drawings and future replacement routes on separate drawings and shall submit to the Engineer for acceptance.
- 11.6.4 The Contractor shall coordinate with interfacing parties on the routes and sequence of construction for equipment delivery. If any temporary openings are required in the plant room floors, plant room walls, etc, within the station box structures, the Contractor shall coordinate with interfacing parties and programme his construction activities for such opening provision to facilitate the delivery of equipment and MEP Modular Units by interfacing parties.
- 11.6.5 The Contractor shall further coordinate with the interfacing parties to produce the **BIM model of Equipment Delivery and Future Replacement Route** based on the largest SWC equipment for the Engineer's acceptance.
- 11.6.6 The Contractor is responsible for designing, supplying, installing, testing and commissioning of all lifting/pulling hooks and beams. Any lifting/pulling hooks, beams and other provisions shown in the Drawings, are not exhaustive. The Contractor shall further coordinate with interfacing parties to produce these model/ drawings for the Engineer's acceptance. The Contractor shall provide all additional requirements as requested by the interfacing parties. Such costs shall be deemed included in the Contract Price.

- 11.6.7 Fixed lifting / pulling points shall be provided for installation and replacement of major pieces of equipment. Each lifting/ pulling point shall be identified and tested to 1.5 times safe working load and certified by a Mechanical Professional Engineer (PE) and/or Authorised Examiner (AE). Copies of such certificates should be submitted to the Engineer for record. In all cases, locations of all lifting/pulling points and their safe working load shall be coordinated and agreed with the interfacing parties.
- 11.6.8 The Contractor shall co-ordinate with interfacing parties and provide decking and staging of the required loading over temporary opening, vent shaft at ground level and ramp from platform level to trackbed so as to facilitate the delivery of E&M equipment and MEP Modular Units. The Contractor shall also provide props along the delivery routes to ensure that loads from the equipment and MEP Modular Units deliveries will not affect the constructed structures. Such costs shall be deemed included in the Contract Price.
- 11.6.9 In the event that an agreement is established between the interfacing parties and the Contractor to deliver the equipment to the plant room with outstanding civil works, the Contractor shall protect the equipment immediately upon delivery to eliminate the risk of damaging the equipment during the process of completing the outstanding civil works.
- 11.7 Water Services, Fire Hydrant System, Sewerage & Sanitary System and Station & Tunnel Drainage System**
- 11.7.1 The Contractor shall provide design, coordination, supply, installation, testing and commissioning of the complete Water Services (including NEWater), Fire Hydrant System, Sewerage & Sanitary System and station and tunnel Drainage System and irrigation system in accordance to the Specifications and design requirement as specified in Civil Design Criteria for Roads & Rail Transit Systems, and the Materials & Workmanship Specification for Civil & Structural Works. The Contractor shall provide the drawings and design calculations fully describing all aspects of the water services, fire hydrant system, sewerage & sanitary systems and station and tunnel drainage systems.

- 11.7.2 The Contractor shall engage Qualified Person (QP) and submit the necessary documents, including design calculation, on Water Services (including NEWater), Fire Hydrant System, Sewerage & Sanitary System, Station & Tunnel Drainage System and Irrigation System to the Engineer for acceptance before submission of the proposals to the relevant authorities and agencies for approval including all applications and any fees for Water Turn On, Temporary Fire Permit (TFP), TOP and CSC. Upon approval from the relevant authorities and agencies, the Contractor shall arrange his QP to inform relevant authorities and agencies on the expected commencement date.
- 11.7.3 A separate contract for the supply and installation of SWC (Water Handling Equipment) (WHE) contract shall be awarded by the Authority. The WHE contract shall consist of pumps and associated pump control panels for Water Services, Sewerage & Sanitary System and Station & Tunnel Drainage Sump Pumping System, and monitoring panels for the seepage holding tank.
- 11.7.4 The Contractor shall provide the necessary information, which include specifications and drawings for the preparation of WHE tender. All submissions where required to statutory authorities of the completed system, including the pumps shall be by the Contractor's QPs/Licensed Plumber (LP).
- 11.7.5 The Contractor shall submit the calculations of the operating pump head and flow rate based on the site coordinated pipe routings and characteristic of the pipework system to be installed for Engineer's acceptance and procurement of WHE.
- 11.7.6 The Contractor shall engage a QP for design work and QP/LP for supervision works and endorsement of the complete systems as-built drawings and calculation. The Contractor's QP and LP shall be fully responsible for the complete installation, testing, commissioning of the water services, fire hydrants system, sewerage & sanitary system and station & tunnel drainage system including WHE.
- 11.7.7 The Contractor shall note that the Authority's drawings only indicate the design intent for the project. It is deemed included that the Contractor shall be responsible to coordinate and develop the full system design based on the latest requirements of relevant authorities and agencies throughout the Contract Period to guarantee the performance of the system.

- 11.7.8 The Contractor shall compile and submit all the test certificates, inspection records, materials, tools, equipment storage, certificates, drawings, temporary works, inspection, testing and incidentals necessary to complete the works in a proper, thorough and skillful manner.
- 11.7.9 The Contractor shall coordinate with adjacent contractors and interfacing parties on the services that route to and from the adjoining contracts.
- 11.7.10 Water Services
- 11.7.10.1 The design and installation of Water Services, including NEWater, shall comply with the requirements from Public Utilities Board (Water Supply) Regulations, latest version of Singapore Standard (SS) 636, the Authority and other relevant authority / statutory boards' requirements.
- 11.7.10.2 The Contractor shall provide the Water Services in accordance to the Specifications and design requirement as specified in LTA Civil Design Criteria for Roads & Rail Transit Systems and Materials and Workmanship Specification for Civil & Structural Works.
- 11.7.10.3 The Contractor shall also engage a QP and LP for the water services works.
- 11.7.10.4 The Contractor shall note that all piping requirements and location of water supply points shown in the Authority's Drawings are for reference. The actual fittings, valves, control etc. shall be designed to meet system and operation requirement.
- 11.7.10.5 The Contractor shall liaise with and obtain approval from relevant authorities and agencies for the connection of PUB water mains to the proposed bulk meter location.
- 11.7.10.6 Risers dedicated to PUB sub-meters serving tenanted areas such as retail units shall be provided in close proximity to the corresponding tenant unit. Tenanted areas shall be provided with a water stub-out and the tenant shall apply for a PUB sub-meter.
- 11.7.10.7 The Cooling Tower Transfer Pumping System shall be designed by the Contractor and the transfer tank shall be designed, supplied and installed by the Contractor, including testing and commissioning.
- 11.7.10.8 The combined sprinkler/hosereel system water tank shall be of Reinforced Concrete (RC) construction and shall be supplied and installed by the Contractor.

- 11.7.10.9 The incoming water supply to the combined sprinkler/hosereel system RC water tank shall be supplied and installed by the Contractor.
- 11.7.10.10 Water points and taps for landscape irrigation, washing and cleaning purposes shall be padlocked.
- 11.7.10.11 The Contractor shall design, supply and install water points, floor traps, temporary power sockets and coordinate with SWC, operators and NParks on power sockets for maintenance and irrigation at every station entrance.
- 11.7.11 Fire Hydrant System
 - 11.7.11.1 General Description
 - 11.7.11.1.1 A private hydrant pump system, if required to serve the development, comprising of hydrant RC tank, pumpsets, control panel, underground hydrant piping, hydrants, etc shall be provided to serve the development. the locations of the hydrants, RC tanks, pumps, control panels shown in the Authority's Drawings are for reference.
 - 11.7.11.1.2 The fire hydrant system including pumps, underground and above ground pipework, RC water tanks, electrical controls, hydrant pillars, water supplies, etc. shall comply with all by-laws, regulations, orders and requirements of both the Fire Safety Department, Singapore Civil Defence Forces (SCDF) and the Building & Construction Authority. In particular, the entire installation shall comply with the current edition of SS 575 and SS 636.
 - 11.7.11.1.3 The Contractor shall provide all fittings piping, gauges, valves, etc. necessary for the RC hydrant tank installation to comply with the requirements of relevant authorities.
 - 11.7.11.1.4 The hydrant pump system shall be monitored by the station's fire alarm system. The Contractor shall be responsible to design, supply, install and terminate the cables between the equipment to Interface Terminal Board (ITB) located in the hydrant pump room to be supplied and installed by SWC (Fire Protection System) (FPS) for the monitoring of the hydrant pump system.
 - 11.7.11.2 Certificates, Permits & Fees

- 11.7.11.2.1 The Contractor shall apply and obtain all necessary certificates and approval from the relevant authorities and agencies for the work done and shall submit all applications and certificates to the Engineer. The Contractor shall also obtain and complete all permits and notices required by the relevant authorities and agencies and shall obtain consents necessary for the various works to be executed. All fees incurred in connection with the applications for the permits and notices shall be deemed included in the Contract Price.
- 11.7.11.3 Hydrant Pump Installation
- 11.7.11.3.1 Pumpsets shall be of the centrifugal, constant speed type and be complete with electric motors, mating flanges, air releases, volute drain connections and base plates. Pumpsets shall be selected for their particular applications in regard to water temperature, ambient air temperature and condition, suction head, static head, lift, working pressure and test pressure. Furthermore, pumpsets shall comply with all governing by-laws, regulations, orders and requirements of all relevant authorities and agencies in respect of the various types of installations.
- 11.7.11.3.2 The Contractor is required to submit the full hydraulic calculations relating to the pressure drop of the equipment selected by them, and of the system piping so that the pumpsets selected and offered are capable of providing the necessary output at the furthest hydrant from the pumps at the minimum head as per code requirements. Pumpsets shall be selected to operate close to the most efficient point on the pump performance curve. Pump performance curves with the predicted operating point shown shall be submitted within four (4) weeks of the award of the Contract. Nominal duties of pumpsets as shown in the Authority's Drawings may be used as approximate guides only.
- 11.7.11.3.3 Pump casings shall be of close grained cast iron or cast steel suitable for the operating pressure and designed to provide smooth flow with gradual changes in velocity. Impellers shall be of bronze and designed to give non-overloading characteristics over large range of head variations.
- 11.7.11.3.4 Pump impeller diameter shall not exceed 0.9 of the maximum impeller diameter capability of the pump housing to reduce the possibility of tonal effect.

- 11.7.11.3.5 Each impeller shall be statically and dynamically balanced to ISO 1940/1, balance quality grade G6.3. Documentary proof of the balancing results shall be submitted to the Engineer for review. Pump shafts shall be of machine ground stainless steel mounted in renewable bronze sleeve, ball or roller bearings. Pump glands shall be of the mechanical seal type but stuffing boxes with bronze glands will be considered as alternatives to the base offer specified. The design speed of all pumpsets shall not exceed 3000 r.p.m.
- 11.7.11.3.6 Each pump shall be directly driven by a totally-enclosed fan-cooled (TEFC) motor. Motors shall be equipped with sleeve ball bearings or roller bearings and speed shall not exceed 3000 r.p.m. The Contractor shall produce manufacturer's selection charts and data to verify that direct coupling of each pump to the related motor will meet the duty specified using standard impellers; otherwise, the Contractor shall provide at his own cost an indirect drive arrangement.
- 11.7.11.3.7 Each pump and motor combination shall be mounted on an inertia block constructed with reinforced concrete providing a weight ratio as specified in the Civil Material and Workmanship Specifications. The depth of the base shall be at least 1/12 the span of the inertia block. The Contractor shall provide complete welded steel channel frames with base plate for the Contractor to cast the reinforced concrete in forming the inertia block.
- 11.7.11.3.8 All pipe fittings, elbows, etc. before the flexible connections shall be rigidly connected to the inertia block. The Contractor shall submit samples of the vibration isolators for review before site construction can commence.
- 11.7.11.3.9 Bolt down type metal guard shall be installed over each coupling with holes neatly cut and trimmed for Tachometer readings.
- 11.7.11.3.10 Fire hydrant pumpsets shall be listed under the Product Listing Scheme.
- 11.7.11.3.11 Jockey pumps shall be capable of delivering a head of approximately 0.7 bar higher than the pressure in the hydrant mains when the hydrant pump is churning. Jockey pumps shall be carefully selected so as to operate on the steep flow characteristic curves and such that when delivering 22.5 lit/min. pump heads shall be around the pressure of the hydrant mains when the pumps are churning.
- 11.7.11.4 Piping, Valves and Fittings

- 11.7.11.4.1 The Contractor shall supply and install all pipeworks and ensure that installation works avoid as far as possible any interference with the work of other trades. The piping systems including all related equipment, fittings, valves, etc. shall be suitable for the design working pressure
- 11.7.11.4.2 Before delivery to site, all pipes shall be thoroughly cleaned, deburred and free from scale, rust, etc. Old and damaged pipes shall be rejected, only new pipes shall be used. On site, all pipes shall be again checked and thoroughly wire brushed and prime coated prior to installation.
- 11.7.11.4.3 All pipe works shall be installed so that clearance of approximately 80 mm is left between the outside of the pipe and the nearest wall, ceiling or equipment surface, whenever possible. Pipes shall be run at such a distance apart to enable them to be individually painted. Pipe joints or fittings will not be permitted within the thickness of walls, floors, any partitions or below a beam.
- 11.7.11.4.4 All straight vertical runs of pipe more than 30 m in length shall have dirt pockets formed from equal tees and plugs at the low point of the risers.
- 11.7.11.4.5 For all pipe connections to valves, strainers and equipment, flanged or screwed joints shall be used.
- 11.7.11.4.6 All elbow, tees and other pipe fittings shall be purpose-made by recognised manufacturers and samples shall be submitted for review by the Engineer before installation.
- 11.7.11.4.7 All drain pipes shall be terminated visibly over the floor grating provided for drainage purposes.
- 11.7.11.4.8 Pipe hangers on all pipes shall be provided and as specified in the M&W Specification for Civil & Structural Works.
- 11.7.11.4.9 Samples of each type of pipe hangers, supports and pipe guides shall be submitted for review before commencement of installation.
- 11.7.11.4.10 All pipeworks shall be installed and tested in accordance with SS 636 and SS 575 and to the approval of the relevant local authorities and agencies.
- 11.7.11.5 Welding

- 11.7.11.5.1 Welding shall be done only by capable, skilled and experienced certified welders. The welders shall only carry out welding works for which he is certified to. All welders' test certificates shall be submitted to the Engineer. Any welder may be asked by the Engineer to carry out a test weld. Should the test weld not meeting the required standard, the Engineer shall have the authority to demand the removal of the welder from the Site. Welds in steel pipes shall be 'V' butt welds and shall be prepared strictly in accordance with B.S. 2633.
- 11.7.11.5.2 All welds carried out shall bear the welder's identification or code. The Contractor shall submit a list of names and identification or code of every welder employed and subsequently to revise the list whenever there is a change of welders working on the Site.
- 11.7.11.5.3 It shall be the Contractor's responsibility to supervise the welding such that no unlisted welders carry out any welding at Site.
- 11.7.11.5.4 All welds shall be thoroughly wire brushed after each welding.
- 11.7.11.5.5 Welding of galvanised steel pipes shall not be permitted.
- 11.7.11.5.6 Immediately after the Engineer is satisfied with the water testing of welded pipes, the pipe welds shall be cleaned, dried, and thoroughly wire brushed again before a layer of primer coating is applied.
- 11.7.11.6 Fire Hydrants
 - 11.7.11.6.1 Hydrants shall be of the pillar type having two (2) 63.5mm nominal bore outlets with external threads matching to the local fire brigade's standard hose threaded coupling connection. The bore of the standpipe should be at least twice the area of the two outlets.
 - 11.7.11.6.2 The outlets shall be provided with protective standard caps of cast iron or other suitable material and attached to the standpipe by chains. All working parts shall be of gunmetal.
 - 11.7.11.6.3 Valve pits of adequate size shall be constructed to house sluice valve complete with surface box, lid, lid key and hydrant key. The topmost of the valve shall not exceed a depth of 1000mm from the ground level.
- 11.7.11.7 Underground Pipe Laying For Hydrant Main

- 11.7.11.7.1 All underground pipeline shall be laid in earth trenches of minimum 750mm depth or concrete trenches. The Contractor shall be responsible for excavation, back-filling and making good the trenches. The Contractor is deemed to have inspected the site, the proposed routes of underground pipelines and nature of the soil and have allowed for all necessary works in connections and gradients required for the pipes and beds as specified.
- 11.7.11.7.2 The trenches should be wide enough to allow careful alignment of the pipe and adequate working space for the layers and jointers.
- 11.7.11.7.3 The bedding for the pipe shall be thoroughly compacted. The pipes shall be laid evenly on the barrel at the required level. There should be no hollows, voids or foreign material under the pipe. Where pipe jointing holes are left in the bedding, particular care must be taken to ensure complete and proper filling of the holes after pipe testing. Where pipes are laid on rock formation, the excavation shall be taken to 150mm below bed level and the bed will then be made up to its true line and level by refilling with 150mm of consolidated material from the excavation, well rammed and watered if necessary.
- 11.7.11.7.4 Where pipes are laid under roads, driveways or vehicle parking areas, continuous concrete bed foundation using 1:2:4 concrete shall be provided. The concrete shall be well rammed or vibrated and worked under and around the pipes to provide minimum 150mm cover all round the pipes. Similar concrete bedding and encasing shall be provided for each and every change in direction of pipeline and at the joints; such encasement shall be for minimum 900mm length before and 900mm length after the change in direction. In any case, the Contractor shall provide for all necessary anchors to resist forces due to pumps, friction, change in direction, etc.
- 11.7.11.7.5 All pipes joints shall be left exposed for inspection during the pressure tests.
- 11.7.11.7.6 The trenches shall only be bottomed up immediately in advance of pipe laying but no pipes shall be laid until a distance of at least 10 metres along the trench has been prepared and bottomed up to receive the pipes. The trenches and joint holes shall be kept free from water until the pipes are laid jointed and surrounded by concrete where required. No water from the trenches will be allowed to enter the new pipes and no back-filling of trenches will be allowed until the joints of the pipes have been tested and inspected.

- 11.7.11.7.7 The Contractor shall include in their cost to employ a registered Civil/Structural Professional Engineer to take charge of the civil/structural aspects of the work. The Contractor shall design and provide all necessary piling for bedding of the underground hydrant main, under the responsibility of their Civil/Structural Professional Engineer. The cost of these works shall be deemed to have been included in the Contract Price. Upon completion of the work, the Professional Engineer to furnish Completion and Inspection Certificates to the Engineer.
- 11.7.11.8 Plugs for Open Pipes
- 11.7.11.8.1 Any open ended pipe or pipe connection shall be protected from the entry of dirt, sand, etc. by the fixing of plastic or galvanised iron sheet cap securely held.
- 11.7.11.9 Expansion Joints and Anchors
- 11.7.11.9.1 Wherever possible, advantage shall be taken of changes in direction of pipes to take up expansion and contraction due to temperature changes of the pipe and its contents.
- 11.7.11.9.2 All vertical pipe anchors shall be resiliently mounted with a layer of minimum 25mm thick neoprene impregnated duck pads such as Mason's type HL or equivalent for loads up to 8.0MPa. For loads up to 0.35 MPa, two layers of 40 durometer, 8mm thick neoprene waffle pads should be used.
- 11.7.11.9.3 All rigidly joined vertical pipes shall be anchored as required to control the movement of pipes due to thermal changes. One anchor shall be provided for each vertical pipe not exceeding 50m in length or fitted in position as required by the Contractor's design to resist movement due to expansion and the weight of the pipe and its contents. Any information shown on the Authority's Drawings is for reference. Expansion joints must be provided between anchors.
- 11.7.11.10 Pipe Guides
- 11.7.11.10.1 The Contractor shall supply and install pipe guides in vertical pipework as specified or required by the Contractor's design or as and when found necessary and as directed by the Engineer. Any pipe guides shown on the Authority's Drawings are for reference.
- 11.7.11.10.2 For pipes 150mm diameter and under, pipe guides shall consist of a layer of min. 8mm thick, 40 durometer neoprene waffle pattern sleeve complete with steel frame for fixing to the walls, floor support and support bracket.

11.7.11.10.3 For pipes 200mm diameter and above, pipe guides shall be installed with a clearance around the pipe as shown in the Authority's drawings. Suitable steel frame with neoprene mounts shall be provided around the circumference to allow for expansion of the pipe column. Pipes shall be installed with be a physical clearance of 2mm between the pipe column and the neoprene pads.

11.7.11.11 Pipe Sleeves

11.7.11.11.1 Pipes passing through walls, floors or any other partitions shall be fitted with pipe sleeves. Sleeves for galvanised or black steel pipe shall be galvanised. Sleeves for copper pipe shall be of brass or copper. Cut edges of galvanised pipe sleeves shall be painted with zinc chromate paint.

11.7.11.11.2 Pipe sleeves fitted in walls or partitions shall end flush with the finished plaster or other surface finish.

11.7.11.11.3 Pipe sleeves fitted in floors shall generally end 15mm above the finish floor level except in Plant Rooms and other areas where 'wet floors' are expected. In these case the sleeves shall end 50mm above the finished floor level, and shall be tightly caulked with ceramic fibre blanket of not less than 96 kg/m³ density.

11.7.11.11.4 Sleeves fitted on insulated pipes shall be over-sized to allow the insulation to be continued through them.

11.7.11.11.5 Where pipes pass through walls, plant rooms, fan rooms, fire brickwalls, floors or other partitions, there shall be sufficient, subject to a minimum of 12mm clearance all-round the pipe and the cast-in sleeve to cater for linear and lateral (in case of branch pipes) movement due to temperature changes. Ceramic fibre blanket of not less than 96 kg/m³ density should be inserted in between the clearance and both sides should be sealed and caulked airtight with a non-setting resilient caulking compound. The pipe shall be supported on both sides of the penetration to maintain uniform clearance between the pipe and the cast-in sleeve.

11.7.11.11.6 Generally, pipe sleeves shall be one nominal diameter larger than the service pipe concerned except for sizes 100mm bore and above where they may be specially constructed from not less than 4mm galvanised sheet steel. In this case, the pipe sleeve shall give 12mm clearance between the service pipes concerned including insulation sheathing.

11.7.11.12 Pipe Fixings

- 11.7.11.12.1 Generally, hangers and supports shall be steel of adequate dimensions and designed to allow for expansion and contraction. All hangers and supports shall be primed and finish coated with black bituminous paint.
- 11.7.11.12.2 In all cases, cradles for pipes 150mm and larger and clamps for pipes below 150mm diameter shall support the pipe independently of any lagging. Special care shall be taken with vapour seals and lagging to ensure they are continuous at points of support. Clamps shall be lined internally with 15mm thickness neoprene strip.
- 11.7.11.12.3 All pipework connected to pumpsets shall be isolated from the building structure by using flexible pipe hangers, anchors and pipe guides. No direct connection between the building structure and any part of the pipework shall be allowed. Where pipes pass through walls or floors a clearance of 12mm around the pipe shall be maintained. Where it is required to seal around the pipe, vibration isolating package shall be used.
- 11.7.11.13 Sewerage & Sanitary Works
 - 11.7.11.13.1 The sewerage and sanitary works installation shall comply with the prevailing Code of Practice on Sewerage and Sanitary Works from PUB, the Authority and other relevant local authorities and agencies.
 - 11.7.11.13.2 The Contractor shall provide Sewerage & Sanitary System in accordance to the Specifications, design requirements, LTA Civil Design Criteria for Roads & Rail Transit Systems and Materials and Workmanship Specification for Civil & Structural Works. Any information on the Authority's Drawings is for reference.
 - 11.7.11.13.3 The Contractor shall note that all piping requirements and location of floor trap/waste, sumps and inspection chambers shown in the Authority's Drawings are for reference. The drawing shown is for concept reference and actual fittings, valves, control etc. shall be designed to meet system and operation requirement.
 - 11.7.11.13.4 The Contractor shall engage a Licensed Plumber to supervise the site installation of sanitary works.
 - 11.7.11.13.5 The Contractor shall liaise and obtain approval from relevant authorities and agencies for the connection of last inspection chamber to sewer manhole.
 - 11.7.11.13.6 All sanitary and drainage services shall be designed and installed with access for maintenance and repairs.

- 11.7.11.13.7 All sanitary waste within this station shall be collected and discharged to public manhole via a dedicated inspection chamber network at Ground Level.
- 11.7.11.13.8 The Contractor shall provide high air pressure and low air pressure test to all the sanitary pipes installed. High air pressure test refers to test to be performed prior to the installation of water closets and floor traps and low air pressure test refers to test to be conducted after water closets and floor traps are installed.
- 11.7.11.13.9 The Contractor shall note that the proposed station sewer pipes may be required to discharge to the PUB's DTSS manhole (MH4A). The Contractor is required to ensure that the sewer design comply with PUB COPSSW and shall submit to PUB(WRN) for approval prior to commencement of works.
- 11.7.11.14 Station and Tunnel Drainage System
- 11.7.11.14.1 The station and tunnel drainage sump pumping system including sumps and pumping installation shall comply with the latest Code of Practice on Surface Water Drainage from PUB, the Authority, BCA and other relevant local authorities and agencies.
- 11.7.11.14.2 The Contractor shall provide drainage system in accordance to the Specifications and design requirement as specified in the Authority's Drawings, LTA Civil Design Criteria for Roads & Rail Transit Systems and the Materials and Workmanship Specification for Civil & Structural Works.
- 11.7.11.14.3 The Contractor shall design and provide seepage water holding tanks to meet his design. Any locations and sizes stated in the Authority's Drawings are for reference.

11.8 Interface Requirements

11.8.1 E&M Interfaces

- 11.8.1.1 The Contractor shall comply with the following interface requirements with E&M System Wide Contractors (SWCs). In the event of discrepancy with **Clause 7** of the Particular Specification, the Contractor shall advise the Engineer accordingly, whose resolution of the discrepancy shall be final and have no impact to the Contract Price or programme.

Within this Clause, the term SWC shall be deemed to include the Authority's Consultants and in-house designers until such time as the Authority appoints the SWCs.

- 11.8.1.2 Isolators and associated cabling from the power supply source to the isolators or fuse connection units for various equipment such as drainage pumps, sewage ejector, hydrant pumps, toilet sensors, shutters, etc. shall be provided by the SWC (Electrical Services). The Contractor shall coordinate with the SWC (Electrical Services) regarding the exact locations of the isolator mountings on the wall and related cable routings.
- 11.8.1.3 The Contractor shall coordinate with the SWC (WHE) on all relevant matters relating to the supply and installation of WHE including but not limited to the locations of the pumps and pump discharge connections, pump motor control panel (PMCP), sump pit and pump sump cover requirement. The typical interface and installation requirements of the Water Services, Sewerage & Sanitary System, Station Drainage Sump Pumping System and Tunnel Sump Pumping System are indicated in **Figures 11.1 to 11.5** below. The Contractor shall work up the necessary flowrates & heads for SWC for selection of their pumps.
- 11.8.1.4 The Contractor shall also be responsible to confirm the pressure and flow of the existing nearest water main so as to verify the adequacy for direct feed for the Cooling Tower System or the requirement of additional pump feed system. All calculations are to be submitted with Contractor QP's stamp to Engineer's record & review.
- 11.8.1.5 The Contractor shall conduct site coordination and provide attendance to SWC (WHE) for the installation of all equipment including to those in stations and tunnels. The contractor shall take lead to resolve any interfacing issue between WHE, and to make adjustment to his provisions to suit the connection to the WHE and other installations.
- 11.8.1.6 The Contractor's QP or Licensed Plumber shall be responsible for the submission to the relevant local authorities and agencies and complete installation, testing and commissioning of the water services, Sewerage & Sanitary Works and Station & Tunnel Drainage Sump Pumping systems including WHE.

- 11.8.1.7 The Contractor shall coordinate with the SWC (Environmental Control System) on the location of the isolation valves for the water supply connection to the chilled water system expansion tank and cooling tower make-up water tank as well as the additional electrodes within the cooling tower make-up tank for start/stop of the pumps. It is also the responsibility of the Contractor to check the adequacy of the break tank for SWC usage. The location of the condensate points and volume of discharge shall be determined through co-ordination with SWC (Environmental Control System) accordingly. The Contractor shall also be responsible to confirm the pressure and flow of the existing nearest water main so as to verify the adequacy for direct feed for the Cooling Tower System or the requirement of additional pump feed system. All calculations are to be submitted with Contractor QP's endorsement for the Engineer's record and review.

- 11.8.1.8 The Contractor shall coordinate with the SWC (FPS) on the location of the isolation valves for the water supply connection to the combined sprinkler/hosereel system RC water tank. It is also the responsibility of the Contractor to check the adequacy of the RC water tank for SWC usage. The combined sprinkler/hosereel system RC water tank shall be supplied and installed by the Contractor.

- 11.8.1.9 The Contractor shall be responsible to liaise with SCDF for the testing of the pressure and flow of the existing nearest fire hydrant/s so as to verify the adequacy for direct feed for the private hydrant/s (if any). If the hydraulic calculation proves that it complies with the SCDF's minimum requirement, the pump feed fire hydrant system shall be omitted and Contract Price reduced. All calculations are to be submitted with Contractor QP's endorsement for the Engineer's record & review.

- 11.8.1.10 The Contractor shall be responsible to liaise with PUB WSN, meter department on the formal approval for the location of the PUB Bulk Water Meter during the design stage, i.e. to determine the water tap off point from the existing PUB water mains for station.

- 11.8.1.11 The Contractor shall coordinate with all SWCs on the confirmation of concrete plinth provisions for E&M equipment mounting/ OG box fixing, slab and wall openings for services penetrations. The location shall not obstruct the commuter passageway from station to or within the serving area.

- 11.8.1.12 The Contractor shall coordinate with the SWC (Electrical Services/respective SWC) for:
 - (a) Underground cabling at ground level for all cast-in pipes, in particular, the cable lead-in pipes;

- (b) Embedded cross-track cable troughs and cast-in pipes at underplatform level and track level;
- (c) Authority and utility civil work requirements;
- (d) Multi cable transit (MCT) units for cable penetrations if require and services lead-in pipes;
- (e) Lamp pole fixing and mounting, etc.;
- (f) Totem poles for exit signage integrating with CCTV/ESC signage where required; and
- (g) Doghouse for services penetrating to roof top and to ensure water tightness to station.

11.8.2 Information Exchange

11.8.2.1 All information and data exchanged between the Contractor and the SWC shall be copied to the Engineer for information. In addition, the Contractor shall refer to **Clause 7** of the Particular Specification for additional coordination requirements and **Appendix B** of the Particular Specification for the information exchange cut off dates.

11.8.3 Control of Sub-Contractors

11.8.3.1 The Contractor shall be responsible for coordinating and controlling the interface activities of his sub-contractors with other SWC and their sub-contractors.

11.8.4 Integrated Testing and Commissioning with the Civil and System-Wide Contractors

11.8.4.1 Before the commencement of integrated testing, the Contractor shall complete the testing of the equipment / system that he has installed.

11.8.4.2 The Contractor shall coordinate with associate SWCs in preparing an integrated test plan to test all the points, equipment and systems. All testing equipment, instruments, tools and manpower required for the testing, which will be witnessed by the Engineer, shall be provided by the respective contractors.

11.8.4.3 Upon completion of testing, the respective SWC shall endorse the test records for submission to the Engineer. Where a failure is recorded in any test, the Contractor and the SWC shall re-schedule another test.

- 11.8.4.4 The Contractor shall be involved in the various integrated testing as indicated in the table below:

S/NO	DESCRIPTION OF TESTS	LEAD CONTRACTOR	PARTICIPATING CONTRACTORS
Integrated Testing and Commissioning			
1	Station Smoke Test	SWC (TVS/ECS)	SWC (ISCS), SWC (FPS), Civil
2	ISCS with SWCs Point to Point and Functional Test	SWC (ISCS)	SWC (SIG/PSD), SWC (PS), SWC (MMS), SWC (COMM), SWC (Lifts), SWC (Escalators), SWC (TVS/ECS), SWC (ES), SWC (FPS), Civil, SWC(AMS), SWC(WHE)
Test Running			
1	Tunnel Smoke Test	SWC (TVS/ECS)	SWC (Trains), SWC (SIG/PSD), SWC (ISCS), Civil

- (i) Lead Contractors to arrange with the Contractor/SWC for access to rooms.
- (ii) The Test Running period is referenced in **Appendix B** of the Particular Specification. The Lead Contractor shall coordinate with the SWC to propose the Test Running programme subject to the acceptance of the Engineer.
- (iii) The list indicated above is non-exhaustive and additional test will be added if it is deemed necessary by the Engineer. The Contractor shall carry out such additional tests at no additional cost to the Authority.

- 11.8.5 Integrated Supervisory Control System (ISCS) Interface Requirements
 - 11.8.5.1 The Contractor is responsible for the design, supply and installation of fire and roller shutters. The Contractor shall be responsible to ensure that the shutters and Fire Hydrant System installed under this Contract are fully interfaced and integrated.
 - 11.8.5.2 The Contractor shall liaise and coordinate with the SWC (ISCS) to mutually agree the communication protocols to be used for all necessary data exchange. In addition, the Contractor shall interface with the ISCS SWC to sign off all interface control document and interface data document produce by the SWC (ISCS).
 - 11.8.5.3 The Contractor shall provide cables connecting and terminating from the shutters to the ISCS via the Interface Terminal Boards, ITBs (provided by SWC (ISCS)) for the control and/or monitoring of the shutters and Fire Hydrant System.
 - 11.8.5.4 Interface Type
 - (a) Isolated voltage-free dry contacts rated at nominal 24V 1A dc each at the shutters control panels are for remote monitoring purposes. Each voltage-free contact shall correspond to a data point of and the shutters. The connections between shutters and ITBs shall be of twisted pair screen cables; and
 - (b) Isolated contacts rated at nominal 48V, 1A dc each with resistive load at the shutters control panels are for each remote control purposes.
- 11.8.6 Information to be provided by the Contractor
 - 11.8.6.1 The Contractor shall provide information to SWC (ISCS) which includes but not limited to the following:
 - (a) Exact number of points and its addresses;
 - (b) Equipment Identifiers / Labels and locations;
 - (c) Communication Protocol; and
 - (d) Functional description of system
 - 11.8.6.2 This information shall be provided in a format to be designed by SWC (ISCS) within a time frame agreed with SWC (ISCS).

TYPICAL I/O POINTS (Indicative only)				
Equipment Description	Point Description	Point Type	Alarm/ Status (A/S)	Remarks
Roller Shutter / Security Shutter / Security Grillers	Open Position	DDI	S	Per Shutter Equipment
	Close Position	DDI	S	
	Trip Status	DI	A	
	Remote Open Control	DO	-	
Fire Shutter FS1	Open Position	DDI	S	Per Fire Shutter
	Close Position	DDI	S	
	Trip Status	DI	A	
Fire Shutter FS2 (Activated by fusible link)	Open Position	DDI	S	Per Fire Shutter
	Close Position	DDI	S	
Fire Hydrant Pumps (Duty, Standby and Jockey)	Pump Run	DI	A	Per Pump
	Pump Trip	DI	A	For Jockey Pump only
Fire Hydrant Tank	Tank High Level	DI	A	Per Tank
	Tank Low Level	DI	A	
	Tank Water Level	VDDI	S&A	
Fire Hydrant Pump Control Panel	Power to Fire Hydrant Pump Control Panel Off	DI	A	Per Control Panel

Note: DI – Digital Input, DDI – Double Digital Input, DO – Digital Output, Virtual Double Digital Input – VDDI

11.8.7 Registration of Data in Maintenance Management System (MMS)

11.8.7.1 The Contractor shall coordinate with the MMS contractor to provide the following as part of the data registration process:

- (a) Provide the listing of the equipment within the scope of supply up to Line Replacement Unit (LRU) level. Equipment Codes shall be used when registering the equipment. The MMS contractor will develop the naming convention document taking reference from the Authority's Asset Information Standard (AIS) for the Contractor's compliance;
- (b) Provide the required data of all other structural and architectural assets;

- (c) Provide the required data describing the equipment. Such data shall include but not limited to details of manufacturers, specifications & descriptions, and other related maintenance information;
 - (d) The Contractor shall provide all data mentioned above in softcopy format such as MS Excel, MS Access or other format to be specified by the MMS Contractor; and
 - (e) Provide equipment labels up to LRU level as registered with the MMS. The Contractor shall print the labels with the Equipment Codes. The Contractor shall ensure that appropriate materials are used for the labels and affix the labels onto the LRUs with suitable means. The Contractor is to note that these labels are to be provided in addition to any other OEM labels provided by the Contractor.
- 11.8.7.2 The Contractor shall ensure that the equipment registered with the MMS are comprehensive and in accordance with his scope of supply, and all data registered are consistent with the provision installed on Site.
- 11.8.7.3 The procedures for the data registration and coordination process shall be defined by MMS contractor for the Contractor's compliance. The finalised data shall be documented, jointly signed by the Contractor and MMS contractor and submitted to the Engineer for acceptance. The Contractor shall complete all equipment data twelve (12) months before the commencement of Test Running.
- 11.8.8 Tunnel Drainage Interface with Adjacent Contractors
- 11.8.8.1 The tunnel drainage sump pump location shall be located at the lowest level of each bound or single bored tunnel. The tunnel drainage discharge pipe leading from the tunnel sump pumps shall be routed directly to the seepage water holding tank via station's vent shaft or service shaft / ducts or mid tunnel escape shaft with separate compartment. Any information shown on the Authority's Drawings is for reference.
- 11.8.8.2 Any tunnel drainage draining beyond the Contract boundaries will be installed by the adjacent civil contractors. The drainage discharge pipes interface at the Contract boundaries shall be in the form of pipe flanges. The Contractor shall be responsible for the final connection of the pipe flanges to any drainage discharge pipes, either provided by the Contractor or adjacent contractors, at the interface boundaries.

- 11.8.9 Interface with Fire Protection System (FPS)
- 11.8.9.1 The Contractor shall provide a voltage free signal via ITBs (supplied and installed by the SWC (FPS)) when the fire shutter is activated by localised smoke detector provided by the Contractor. The SWC (FPS) will provide one ITB to each group of fire shutters that are located within close proximity. The SWC (FPS) shall supply and install the wiring and connections between the fire alarm system and the ITBs. The Contractor shall supply and install the localized smoke detectors, and the wiring and connection to the ITBs and the fire shutter control panels.
- 11.8.9.2 The Contractor shall coordinate with the SWC (FPS) for the interfacing requirements between the fire shutters and the fire alarm system.
- 11.8.9.3 The Contractor shall coordinate with SWC (FPS) on the locations of puddle flanges to be cast-in and ensure that the position of the flanges is at the correct FFL for the combined sprinkler/hosereel RC water tanks. In the event where the SWC (FPS) has yet to be appointed, the Contractor shall provide the cast-in pipe sleeves c/w puddle flanges and shall coordinate with CR2007 consultant on the locations and positions to be cast-in items.
- 11.8.9.4 The Contractor shall supply, install and terminate the cables from the hydrant pump control panels to the Fire Alarm System via the ITB (supplied and installed by the SWC (FPS)) for monitoring. The ITB shall be located within the hydrant pump room but the exact location shall be co-coordinated between the Contractor and the SWC (FPS).
- 11.8.9.5 The Contractor shall provide the following status monitoring points to the Fire Alarm System in the form of voltage free contacts.
- (a) Tank low Level for each fire hydrant tank compartment.
 - (b) Tank high Level for each fire hydrant tank compartment.
 - (c) Pump Start/Stop for each fire hydrant pump.
 - (d) Pump Trip for Jockey Pump.
 - (e) Fire hydrant pump control power status.

11.9 Labels and Reference Plates

- 11.9.1 All equipment shall be clearly and permanently labelled in English for identification and warning, to the acceptance of the Engineer. Where labels are provided for making clear the method of operation of apparatus they shall be concise and preferably diagrammatic in form.
- 11.9.2 All parts shall be identified with the original manufacturer's name and part number in addition to any part number assigned by the Contractor.
- 11.9.3 All labels, number plates and warning notices shall be permanent, durable and corrosion resistant materials securely fitted by approved permanent fixings and clearly and indelibly worded. For outdoor use they shall remain legible and not suffer degradation from weathering throughout the specified life of the equipment.
- 11.9.4 Warning notices shall have red lettering on a white background. The word 'Danger' shall be prominent and have larger letters than other parts of the inscription. All other labels and numbering plates shall have black lettering on a white background.
- 11.9.5 The size of letters and nature of the wording shall be to the Engineer's acceptance.
- 11.9.6 Labels for similar assets shall be of uniform appearance, texture and size.
- 11.9.7 The Contractor shall submit a schedule of labels for the Engineer's acceptance before engraving is carried out.
- 11.9.8 Asset labels shall be provided and permanently installed by the Contractor for all equipment. The Contractor shall submit the final format and size of the labels as well as the installation layout of the labels on the respective equipment, to the Engineer for acceptance.
- 11.9.9 Inscriptions application processes on asset labels that may deteriorate due to fading or abrasion are not acceptable.
- 11.9.10 Fixings of labels onto assets by permanent mechanical means such as screws, rivets or equivalent are acceptable. Use of adhesives is not acceptable (unless there are no other alternatives or agreed with the Authority).

11.10 Photovoltaic (PV) System

- 11.10.1 The Contractor shall design and provide the required civil provisions for the PV (Photovoltaic) system at all station entrances and at-grade structures including RC and metal roofs. The Contractor shall coordinate with the Authority's In-house Designers and SWC on the PV system requirements.
- 11.10.2 The Contractor shall make the necessary civil and structural provisions for installation of PV system including but not limited to wall openings, closets, cable risers, maintenance access to roof, fall arrest system and other requirements to comply with prevailing requirements from authorities having jurisdiction.
- 11.10.3 The Contractor shall coordinate with the Authority's In-house Designers on the type of roof and the method of securing the PV modules onto the roof. In the event special provisions are required to secure the PV modules onto the roof in order not to affect the integrity and waterproofing of the roof, these special provisions are deemed included in the Contract Price.
- 11.10.4 The Contractor shall coordinate with the Authority's M&E Consultant on the structural loading of the PV module on the roof. In the event the structural loading of the roof is insufficient to hold the PV modules, the Contractor shall make provision to strengthen the roof in order to accommodate the PV modules on the roof at no additional cost to the Authority.
- 11.10.5 The Contractor shall provide all temporary works required (i.e. scaffolding/staging, mobile platform, lifting/hoisting equipment, etc.) for the delivery, installation, testing and commissioning of the PV system.
- 11.10.6 The Contractor shall coordinate and maximize roof space for the installation of the PV system as required by the Authority.
- 11.10.7 The Contractor shall include the PV system in all the statutory submissions to relevant authorities.
- 11.10.8 The Contractor shall provide temporary protective barriers all around the roof of the building where the PV modules are to be installed to prevent workers and objects from falling off the roof.

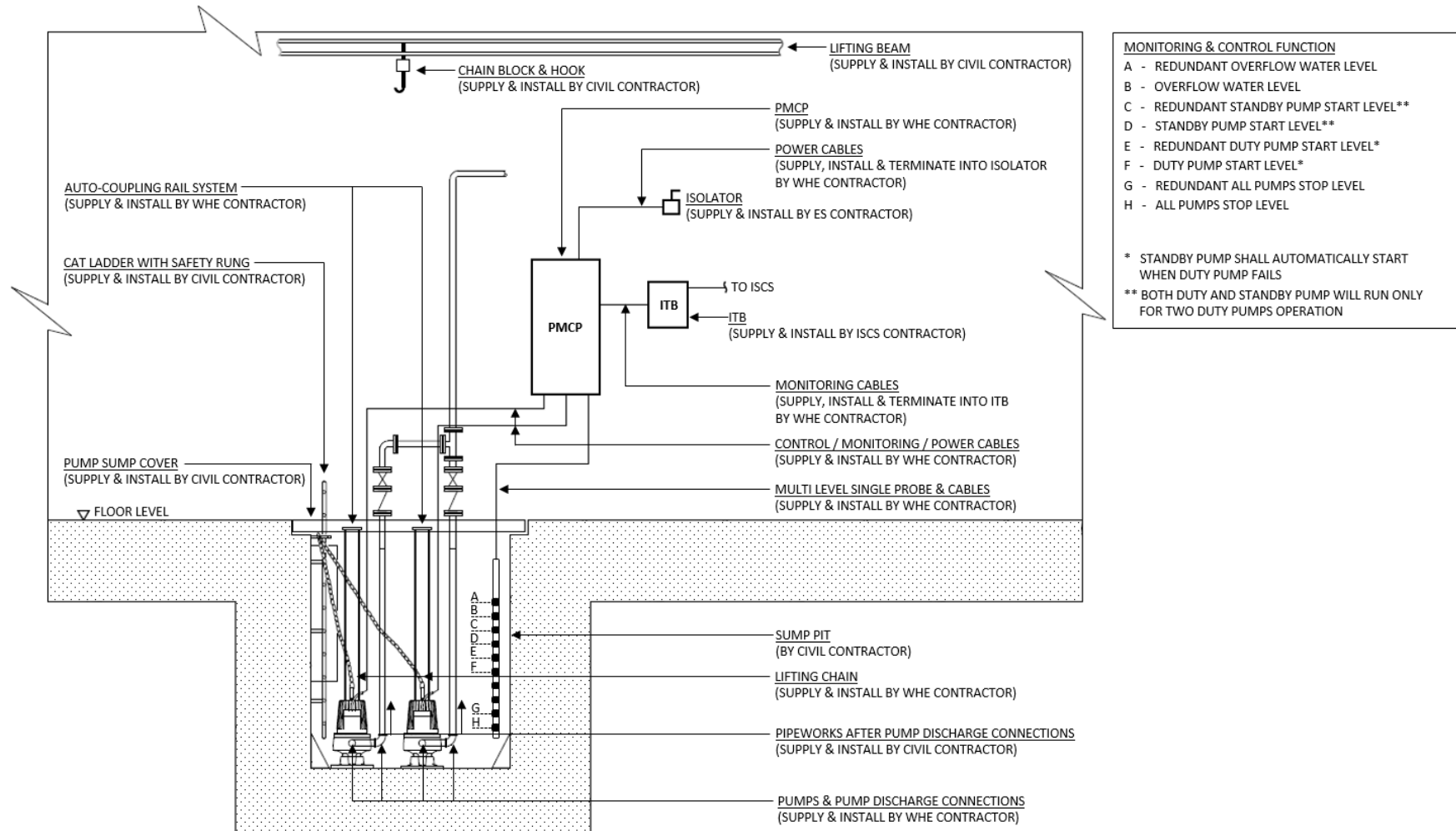


FIGURE 11.1: TYPICAL INTERFACE & INSTALLATION REQUIREMENTS OF STATION DRAINAGE SUMP PUMPING SYSTEM

PS-11-33

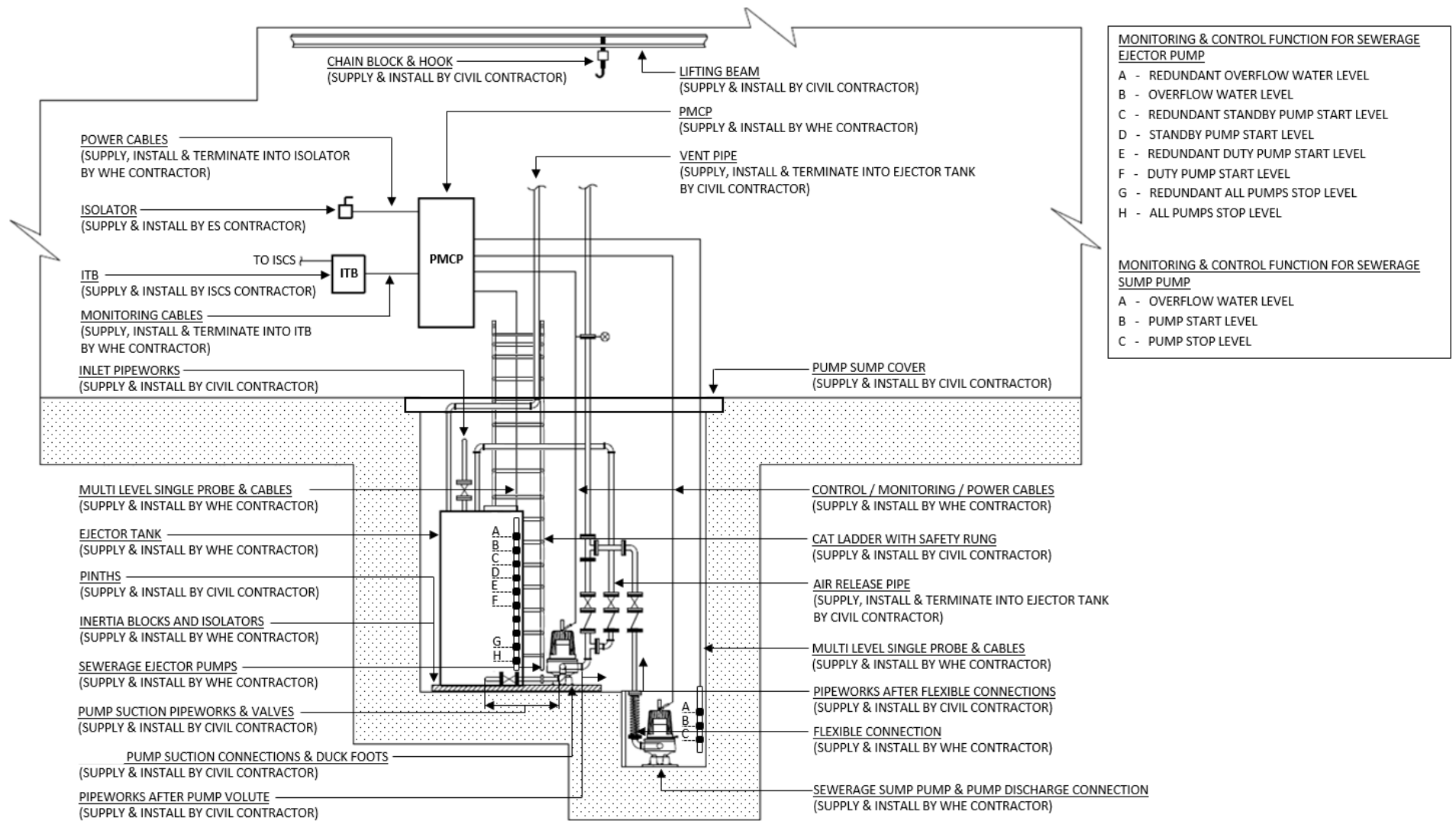


FIGURE 11.2: TYPICAL INTERFACE & INSTALLATION REQUIREMENTS OF SEWERAGE EJECTOR PUMPING SYSTEM

PS-11-34

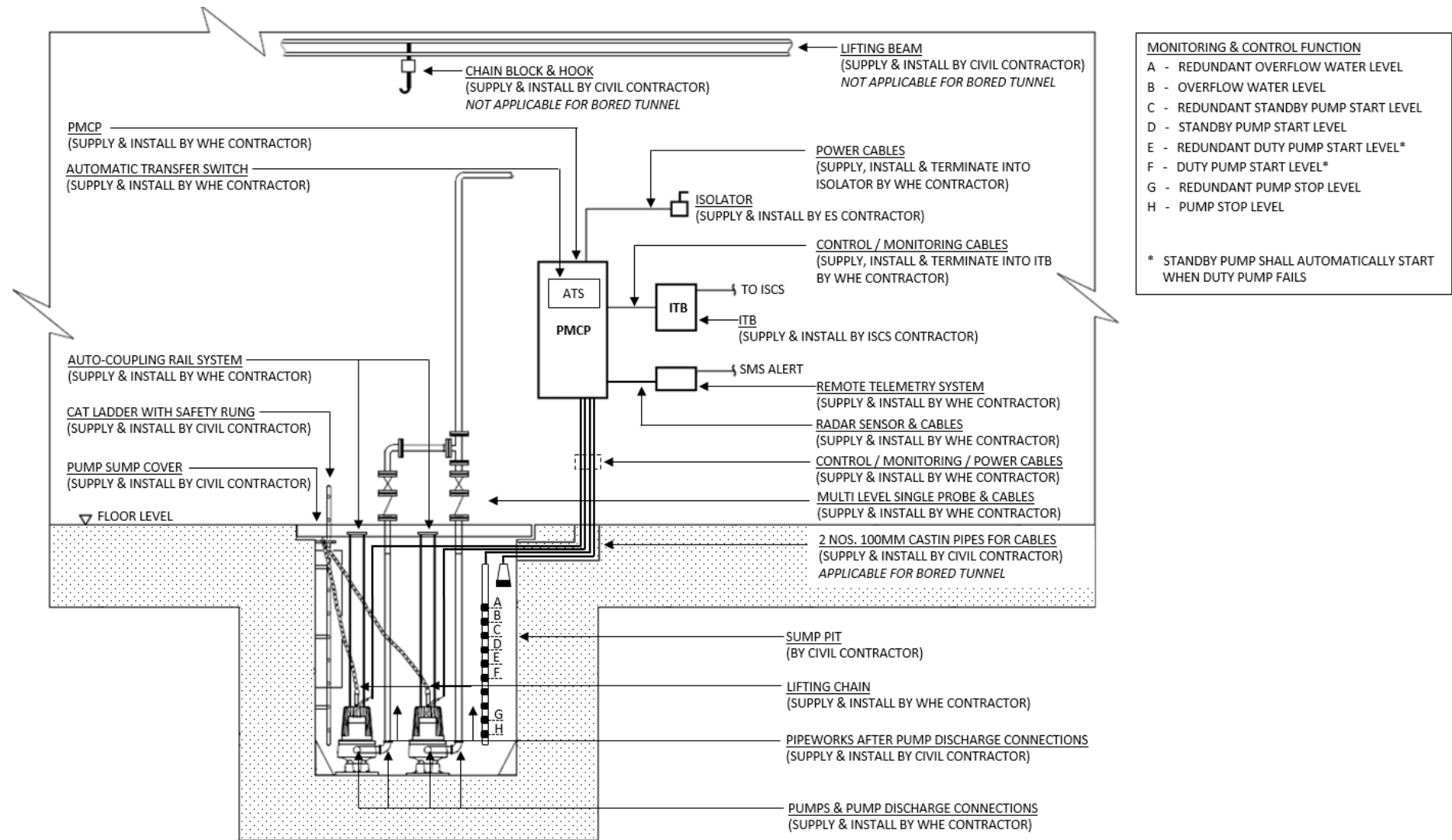


FIGURE 11.3: TYPICAL INTERFACE & INSTALLATION REQUIREMENTS OF TUNNEL DRAINAGE SUMP PUMPING SYSTEM

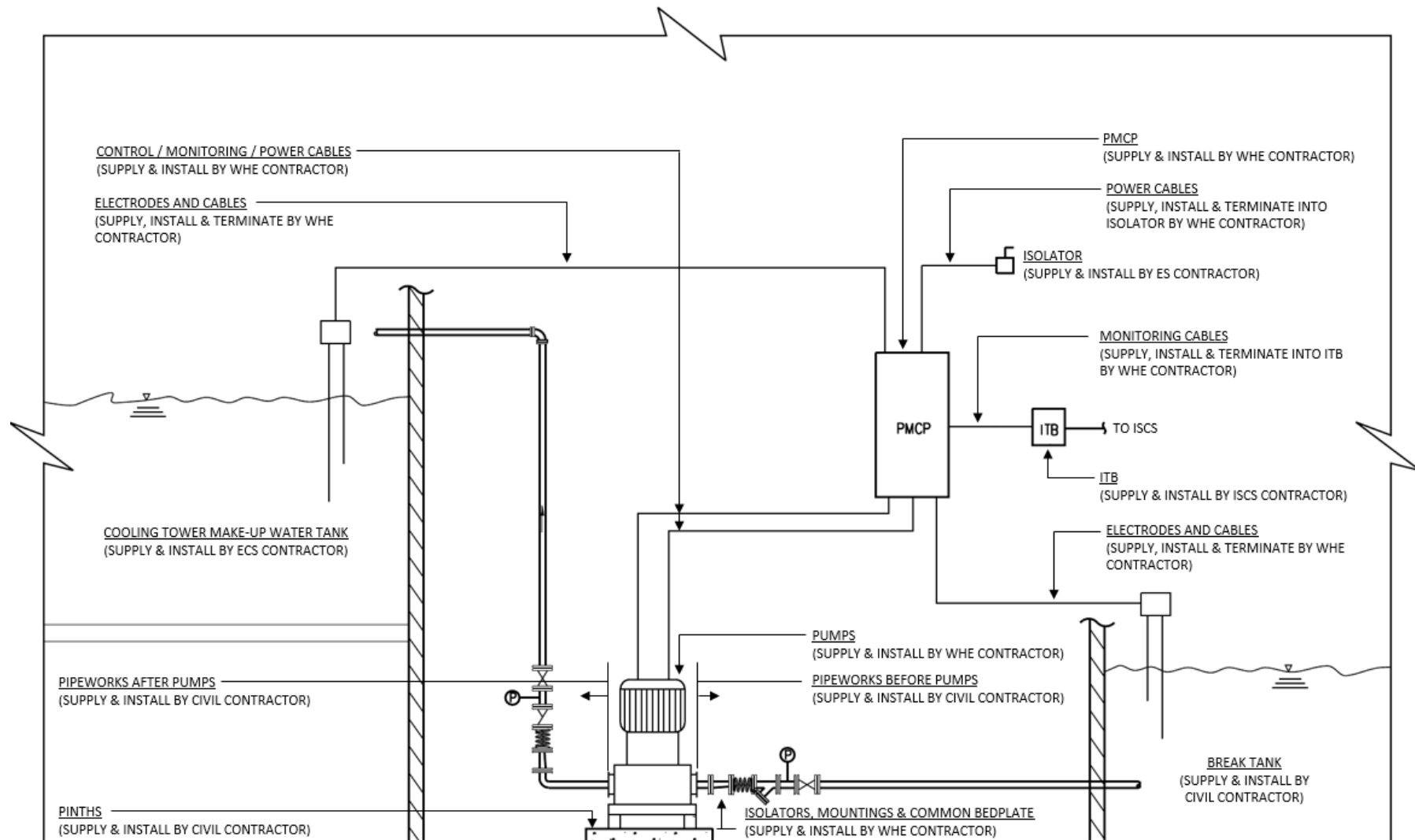


FIGURE 11.4: TYPICAL INTERFACE & INSTALLATION REQUIREMENTS OF TRANSFER TANK AND WATER PUMPING SYSTEM TO COOLING TOWER MAKE-UP TANK

PS-11-36

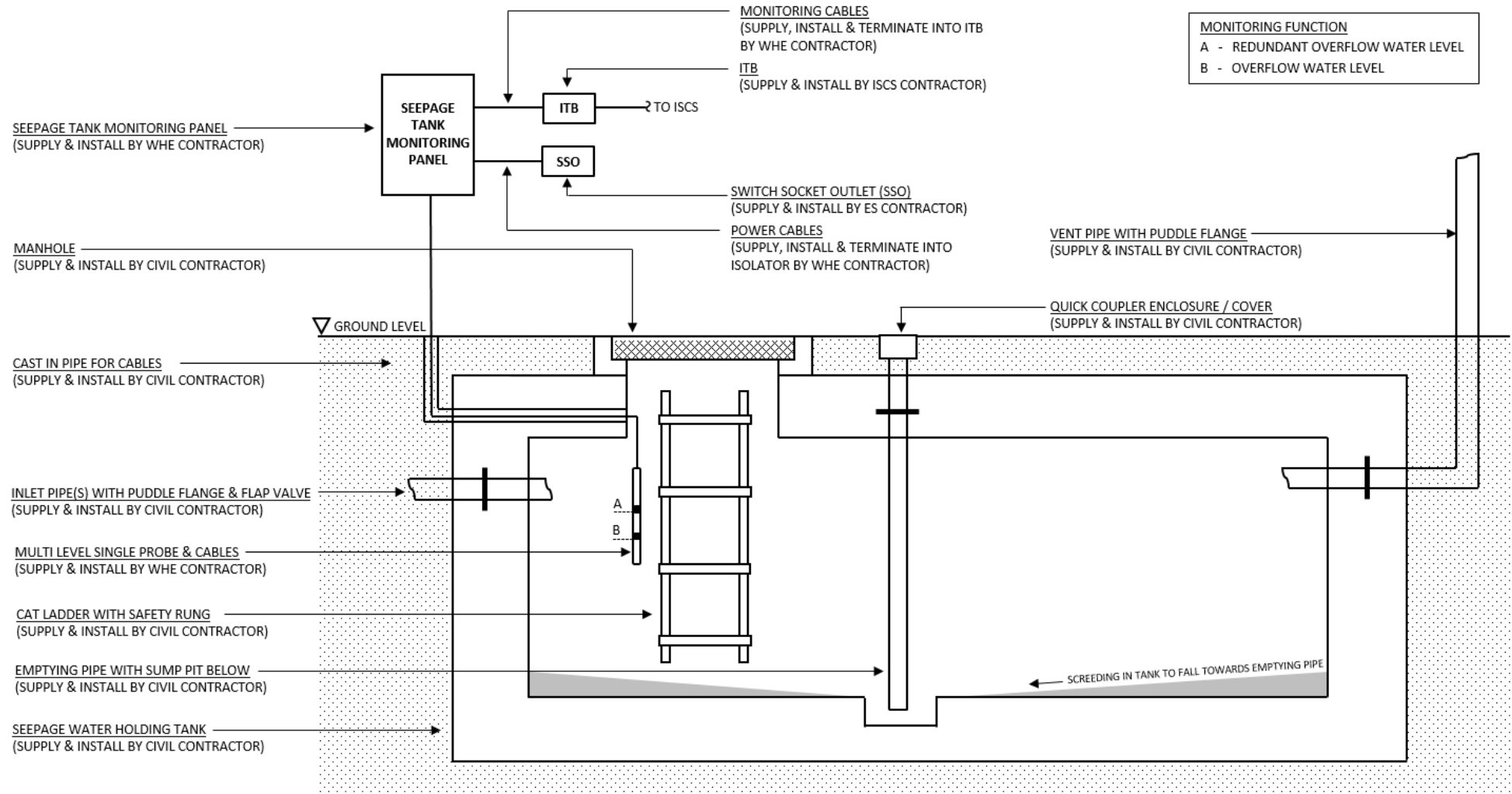


FIGURE 11.5: TYPICAL INTERFACE & INSTALLATION REQUIREMENTS OF SEEPAGE WATER HOLDING TANK