SECTION 8: DRAINAGE, SEWER AND WATER SUPPLY NETWORKS

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SECTION 8.01 DRAINAGE, SEWER AND WATER SUPPLY NETWORKS: GENERAL REQUIREMENTS

8.01.1 SCOPE

A. The work covered in this section includes the supply of materials, installation, testing and commissioning of all pipes, fittings, valves, and appurtenances related to:

- The provision and construction of a stormwater drainage network including pipes, ditches, manholes, catchpits, catch basins, interceptors, access shafts, discharge points and connections to existing culverts.
- The provision and construction of wastewater collection networks including pipes, manholes and connections to existing sewers.
- The provision, construction and connection of water supply networks including pipes, valves, couplers and all other accessories.

B. The work consists of finishing all materials and the construction installation and completion in all respects as described in this Specification and as shown on the Drawings.

8.01.2 SPECIAL REQUIREMENTS

A. **Manufacturer's Certificate**: Materials shall be supplied with a certificate, in respect of each delivery, stating that products comply with and have been factory tested in accordance with the specified Standards.

B. **Marking**: Unless otherwise specified in the relevant Standard, products shall have legibly cast, stamped or indelibly painted on, the following marks, as appropriate:

- The manufacturer's name, initials and identification mark.
- Nominal diameter.
- Class designation.
- Initials and number of relevant Standard.
- Length of pipe if shorter than the standard length.
- Angle of bends in degrees.
- The date of manufacture.

C. Special Tests: Whenever required by the Engineer, the Contractor shall supply and transport to an approved testing laboratory samples of materials selected by the Engineer. The number of samples shall not be less than 0.5% of total supplied, with at least one from each class, diameter and manufacturer. Failure of any sample shall be followed by a second and if necessary a third test from the same batch. A third test failure will result in all material from that manufacturer being rejected and replaced by material from a different manufacturer, subject to approval by the Engineer, after satisfactory testing. Laboratory test reports in an approved form shall be provided.

8.01.3 WORKMANSHIP: OPERATIONS

A. Manufacturer's recommendations on handling, repairing, laying, jointing, anchoring, testing and other works for pipes and fittings shall be strictly followed.

B. The Contractor shall use cranes, hoists or forklifts as directed by the Engineer. The Contractor shall use hooks, spreader beams, ropes, band or wire slings etc. as recommended by the manufacturer for each type of pipe and as approved by the Engineer.

C. The Contractor shall stack pipes on a level surface. Pipes shall not rest on sockets or flanges and end pipes in the bottom row shall be securely chocked. Heights of stacks shall be in accordance with the manufacturer's instructions.

D. The Contractor shall handle material with care to avoid damage whenever moved by hand, forklifts or hoists.

E. The Contractor shall provide safe storage for all material. The interior of pipes, fittings etc. shall be kept free from dirt and foreign matter. The Contractor shall provide shade for materials as required by manufacturers' instructions and recommendations and to the Engineer's approval.

F. Cutting: The Contractor shall use hacksaws, manually operated wheel cutter or pipe cutting machine in accordance with manufacturers' instructions. If, in the opinion of the Engineer, special precautions are required to eliminate airborne particles, the Contractor shall use methods and equipment as directed by the Engineer. The Contractor shall prepare ends according to type of joint used and follow manufacturers' recommendations. The Contractor shall take care not to damage linings. The Contractor shall repair on site minor damage if so permitted by the Engineer.

G. The Contractor shall repair damaged coatings, sheathings or linings in accordance with the Specification and the manufacturer's instructions. The Contractor shall use material compatible with that originally used. Repairs shall be approved by the Engineer before incorporating the materials into the works.

8.01.4 SEQUENCE OF CONSTRUCTION

The Contractor shall adhere to the sequence of construction as set out below unless a justified request for modification is approved by the Engineer at least two weeks prior to commencement of work on the affected section of the network:

- Stake out pipe alignments
- Clear and grade the right of way (wherever required)
- Carry out surveys, including trial pits if necessary, along the alignments to verify the location, depth, size and type of existing utilities.
- Prepare and submit for approval composite Shop Drawings for all utilities showing alignment, ground elevation, trench invert elevation, pipe size, class and length, station and size of fittings, valves as applicable manholes, inlets, appurtenances and structures to be demolished and reinstated (kerbstone, rails, culverts, etc.). Cross sections showing location and inverts of existing pipes and those proposed shall be prepared. Pipes, structures and other utilities to be removed or relocated shall be indicated on the Shop Drawings.
- Relocate, demolish and reinstate existing services and utilities interfering with pipeline alignments.
- Remove pavement layers, excavate trenches and place bedding as required
- Lay and join pipes, fittings, appurtenances, manholes, etc.
- Place primary backfill material
- Perform hydrostatic testing
- Complete connections to existing services and curb/gutter inlets as required
- Place final backfill
- Restore or reinstate surfaces and structures as required
- Carry out final surface works road surfacing curb stone, backing walls, sidewalk paving, etc.
- Dispose of surplus materials.

8.01.5 RIGHT OF WAY

A. Extent

A.1 All utility services shall be installed in the right-of-way of existing or proposed roads as shown in the Drawings, typical cross sections and the utility provider's requirements.

SECTION 8.02 PIPES AND APPURTENANCES

8.02.1 SCOPE

A. The work covered in this section includes furnishing and installing pipes for surface water, drains and sewers as and where shown on the Drawings including jointing, connections to other pipes and drainage structures and backfilling.

B. Drainage, sewer and water supply work shall be in accordance with the requirements of Section 8.01 of the Specification.

8.02.2 MATERIALS

A. Concrete Pipes (for Sewage and Drainage)

A.1 Precast concrete pipes shall be manufactured in accordance with BS EN 1916: 2002 Class H. Cement used in manufacture shall be Ordinary Portland Cement to BS EN 197-1:2000.

A.2 Joints shall to be the gasket type with flexible spigots and sockets. The shape of the joint shall be designed to prevent any movement of the gasket during assembly and to be watertight. Rubber gaskets shall be manufactured to BS EN 681-2:1996.

A.3 The inside faces of pipes for sewer networks shall be lined as follows:

- For pipes smaller than 900 mm diameter a coal tar epoxy coat 70% minimum epoxy content shall be used. The minimum thickness of the coat shall be 1mm.
- For pipes 900 mm and larger a polyethylene liner shall be used.

A.4 For internal and external faces of concrete pipes for drainage networks and external faces of concrete pipes for sewer networks linings are not required.

B. Ductile Iron Pipe (for Water Supply)

B.1 Pipes shall be manufactured to BS EN 545:2002. Unless otherwise indicated in the Bill of Quantities. Class K9 pipes shall be used for diameters up to 500 mm, Class K8 for diameters from 500 to 800 mm and Class K7 for diameters greater than 800 mm.

B.2 Spigot and socket ended pipe joints shall be used for straight runs and adjacent to elbows or fittings. These joints shall be provided with rubber gaskets, and external thrust blocks at elbows or fittings. Anchored or self restrained joints shall be used for sections on 1000 mm pipes adjacent to elbows. Anchored joints shall be the push-in, self anchored type. Concrete thrust blocks are not required for anchored joints. The Contractor shall submit calculations verifying the number of restrained joints required noting that pipe pressure testing will be made when pipes are partially backfilled.

B.3 Joints: flanged pipes wherever specified shall have screwed-on or cast-on flanges to sustain a minimum working pressure of NP 16 minimum.

B.4 Flanges shall be provided in accordance with BS EN 1092-1:2002.

B.5 Factory protection for pipes shall be as follows:

- Internally: cement lined to BS EN 545:2002 with ordinary Portland cement to BS EN 197-1:2000 to the thickness specified on the Drawings or as instructed by the Engineer.
- Externally: metallic zinc shall be applied in accordance with BS EN 545:2002 either hot applied coal tar material to BS 4164:2002 or bitumen to BS 3416:1991, minimum thickness 150 microns.

B.6 Factory protection for fittings shall be as follows:

Coated internally and externally by dipping, or other method, using hot applied coal tar based material to BS 4164:2002 or hot applied bitumen to BS 3416:1991, Type 1, grade D, minimum thickness 250 microns.

C. UPVC Pipes

C.1 Pipes shall be manufactured in accordance with DIN 8061/8062, Series 4 and 5 or ISO 161-1:/4422 Class 10 and & 16. Concrete encasement shall be used if the cover is less than 1.2 metres.

C.2 Fittings shall be manufactured in accordance with DIN 8063 part 1 fabricated from pipe.

C.3 Joints shall be manufactured in accordance with DIN 8063 Part 1, socket spigot with rubber sealing rings to BS EN 681-1:1996.

D. Polyethylene (PE) Pressure Pipe for Water Supply and Irrigation

D.1 Pipe and fittings shall be manufactured in accordance with DIN 8074/8075 or AWWA C906-99. Pipes shall be supplied straight with straight ends suitable for heat fusion, class 10 and 16 kg/cm^2.

D.2 Materials used shall have a minimum hydrostatic design basis of 1600 psi according to AWWA C906-99 Table 1.

D.3 Manufacturers shall provide certification that stress regression testing has been performed on the pipe products. Materials shall also meet elevated temperature requirements as given in Table 2 AWWA C906:99.

D.4 Fittings shall be manufactured in accordance with AWWA C906-99, extruded or injection moulded suitable for the class of pipe required.

D.5 Joints for pipes and fittings shall be made by heat fusion and in strict accordance with the pipe manufacturer's recommendations. Joints shall have a tensile strength equal to that of the pipe. Fusion temperature, interface pressure, alignment and cooling time, shall be according to the manufacturer's recommendations.

D.6 Where PE pipes are to be used for potable water supplies, PE compounds in pipes and fittings shall contain no toxic chemicals that can migrate into the water. PE compounds shall be tested and certified suitable for potable water by an accredited testing agency as approved by the Engineer. Tests shall be undertaken in accordance with requirements no less restrictive than those in NSF Standard No. 14 (1976), Sections 3 and 4. The seal and mark of the testing laboratory shall be included on pipes and fittings.

E. Glass Reinforced Plastic (GRP) Pipes

E.1 GRP pipes and fittings shall be manufactured in accordance with BS 5480:1990. Resins, surface tissues and fibrous reinforcement shall be in accordance with clause 3; pipes and fittings shall be supplied with a resin rich corrosion liner consisting of a layer of 'c' glass backed by a layer of 'E' glass impregnated with resin - with a nominal thickness of 1.0 mm and an outer layer with a minimum thickness of 0.2 mm. The sand content shall not exceed 50%. GRP pipes shall have the following properties: -

- Stiffness: minimum 5000 N/m^2. Suitability of stiffness shall be verified by Contractor for the various trench and pipe laying conditions and as recommended by the manufacturer.
- Longitudinal strength: to BS 5480:1990 table 2.
- Strain corrosion resistance: tests are to be carried out in accordance with BS 5480:1990 with a strain corrosion value at 50 years to equal or exceed 0.7%.
- Markings: to BS 5480:1990 clause 11.
- Joints: GRP double socket couplings or bell and spigot type with rubber rings to BS EN 681-1:1996. Allowable angular deflection shall be in accordance with BS 5480:1990 Table 3.

E.2 Testing on GRP pipes: The following tests shall be carried out on manufactured pipes. Details of the testing programme shall be submitted to the Engineer for review and approval prior to commencement of pipe manufacture. The manufacturer quality control scheme shall be to BS EN ISO 9001:2000. Guidance on quality control and sampling shall be BS 5480:1990 Appendix Q. The following tests shall be carried out in accordance with BS 5480:1990 and reported to the Engineer for approval.

- Longitudinal strength
- Hydraulic test.
- Stiffness
- Wall thickness
- Diameter
- Hardness
- Loss of ignition

F. Steel Pipe

F.1 Steel pipes of size 150 mm and smaller shall be black steel, seamless or welded, and shall conform to BS 1387:1985 medium class, or ISO 65:1981.

F.2 Steel pipes of size 200 mm and larger shall be welded black steel, and shall conform to BS EN 10216:2002 or BS EN 10217. Minimum wall thickness shall be in accordance with to BS EN 10220:2002 or as given in the Bill of Quantities.

F.3 Steel pipe shall be round and straight and free from injurious defects. Defects shall be considered injurious when the depth of defect is greater than 12.5% of the tabulated wall thickness. Pipe shall be free from rust.

F.4 Steel pipe shall be joined by double submerged arc welding in accordance with BS EN 10311:2005. All welding shall be performed in conformance with the rules and regulations of the American Welding Society, including surface preparation methods, welding procedures and the qualification of welders and welding operators.

F.5 Surface preparation: Prior to coating, the surface shall be prepared by acid pickling until all scale has been removed.

F.6 Internal lining: All steel pipes and specials shall be lined internally to the thickness specified with concrete made from ordinary Portland cement to BS EN 197-1:2000 and fine aggregate. The materials used for lining, the method of lining and curing of the finished lining and the manufacture and testing of test cubes shall comply with BS EN 10224:2002 and shall be carried out to the approval of the Engineer.

F.7 External coating: steel pipes fittings and specials shall be protected externally with bituminous laminate tape 1.6 mm thick and with a 55% overlap or as recommended by the manufacturer.

G. Flanged Adaptors: Ferrous

G.1 Ferrous flanged adaptors shall be manufactured in accordance with BS EN 545:2002 from cast iron to BS EN 1561:1997 grade 14 or mild steel plate to BS EN 10210 4SA and malleable cast iron flanges to BS EN 1562:1997 310 grade 20/10 or rolled steel to BS EN 10084 - 060A12 with bolts to BS EN 10084:1998 - EN3A and rubber rings to BS EN 681-1:1996.

G.2 The lengths of adaptors shall be 200 mm for diameters up to 150 mm, 250 mm for diameters between 200 and 300 mm and as approved by the Engineer for diameters larger than 300 mm.

G.3 Factory protection: Adaptors shall be coated with bitumen or coal tar to BS 3416:1991 or BS 4164:1987 respectively.

H. Tapping Saddles: Cast Iron

H.1 Type: Tapping saddles shall be suitable for tapping ductile iron pipe and for a working pressure of 16kg/cm^2.

H.2 Material: Saddles shall be manufactured from malleable cast iron, ductile cast iron or gunmetal to BS EN 1562:1997 310 - B310/10, BS EN 1563: 1997 - 420/2 or BS EN 1982:1999 LG2- C respectively, with rubber '0' ring to BS EN 681-1:1996 suitable for water supplies and manganese bronze high tensile non- corrosive bolts, nuts and washers.

H.3 Dimensions: saddle widths shall not be less than 38 mm and diameter of discs not less than 75 mm.

H.4 Threads for tapping shall be manufactured in accordance with BS EN 10226-1:2004

H.5 Factory protection shall be hot bitumen dipped to BS 4164:2002 or cold bitumen coated to BS 3416:1991.

8.02.3 WORKMANSHIP

Earthworks for pipelines shall be constructed in accordance with Section 2.10 of the Specification.

A. Pipe Laying and Jointing - General

A.1 Pipes shall not be lowered into trenches until the pipe bed is brought to grade and approved by the Engineer.

A.2 Pipes shall be lowered using ropes, wire slings, band slings and spreader beams as recommended by the pipe manufacturer for each type of pipe and approved by the Engineer.

A.3 All materials shall be examined for damage. Tests shall be undertaken in accordance with the manufacturer's instructions and to the satisfaction of Engineer before installation.

A.4 The Contractor shall ensure that all internal coatings and linings and outer coatings or sheathing are undamaged. Damaged areas shall be made good or disposed of as directed by the Engineer.

A.5 Dirt and other materials shall be removed from pipes before lowering.

A.6 Construction debris shall be cleared from the inside of pipes before making joints.

A.7 Pipes shall be laid on an even formation true to grade and line, with sockets (if any) facing up the gradient.

A.8 Holes shall be cut in the trench formation to allow for correct jointing and for barrels of pipes to bear evenly on solid ground for their full length.

A.9 Bedding material shall be scooped out locally at sockets/couplings to enable pipes to rest uniformly on barrels and adjusted to the exact line and level. After testing, granular surround material shall be laid and compacted in 150 mm layers or as directed by the Engineer to levels shown on the Drawings.

A.10 Rectangular blocks of concrete Class B shall be provided for pipes on concrete bed or surround. The blocks shall be made in approved moulds at least 14 days before use with hardwood folding wedges. Two concrete blocks shall be provided for each pipe, set and boned to the correct level on the formation and the pipe laid centrally and socketed. Two hardwood folding wedges shall be inserted, of widths equal to the width of the concrete blocks, between the body of the pipes and blocks and driven together until the pipes are brought to the exact level required. Blocks and wedges shall be left undisturbed while pipes are being jointed and the concrete bed and haunch or surround are being placed. Blocks and wedges shall be of sufficient size and strength to prevent settlement of pipes. Sufficient space shall be left to enable joints to be made, tested and inspected.

A.11 When pipe laying is not in progress, open ends of pipes shall be closed with properly fitted temporary wooden plugs or standard caps as approved by the Engineer.

B. Jointing

B.1 Manufacturers' instructions shall be followed regarding placement of bedding and backfilling, cleanliness of joint surfaces, the lubricant used, the correct location of components and the provision of correct gaps between ends of spigots and backs of sockets.

B.2 Flexible joints shall not be deflected beyond the maximum permissible angles given by the manufacturer and/or relevant Standard.

B.3 Patent detachable and flexible joints shall strictly comply with special instructions issued by the manufacturers of proprietary joints when laying and jointing.

B.4 Differing pipes and fitting material shall be jointed with adaptors as recommended by the pipe manufacturer.

C. Line and Gradients

C.1 In open excavations sight rails and boning rods shall be provided and correctly maintained and painted to ensure the correct alignment of pipe runs. Sight rails shall be positioned either vertically above the lines of pipes or immediately adjacent thereto. At least three sight rails shall be provided for each length of pipeline under construction to any one gradient.

C.2 In headings marks shall be provided and maintained to establish the line and level of pipelines. Marks shall be fixed in each working shaft and two further marks established in each length of heading.

D. Tolerances

D.1 For gravity sewers tolerances shall be 6 mm in level and 25 mm in line between manholes or access points unless otherwise specified or approved by the Engineer. Where pipes are to be constructed in straight lines between manholes, the length will not be accepted if a light shone from each manhole cannot be seen from adjacent manholes.

E. Floatation

E.1 Whenever water is excluded from the interior of pipes, sufficient backfill shall be placed above the pipes to prevent floatation.

E.2 In the event of any pipe floating, the pipe shall be removed and relaid to the correct line and level.

F. Pipes Built into Structures

F.1 Treatment of external surface: Outside surfaces of pipes to be built-into structures shall be thoroughly cleaned immediately before installation. Protective coatings to metal pipes shall be removed when specified. Clay and concrete pipes shall be roughened as directed on the drawings or instructed by the Engineer. Plastic pipes shall be painted with appropriate solvent cement and sprinkled with dry coarse sand whilst wet. Sheathing shall be cut away from sections to be built-in and protection shall be restored up to the external faces of structures with appropriate bituminous material after installation.

F.2 Two flexible joints or flexible patented joints shall be provided adjacent to each structure. The first joint shall be placed not more than one pipe diameter from the face of the structure and the second joint not more than the following distances away from the first:

- Pipelines not exceeding 450 mm: 2 pipe diameters
- Pipelines over 450 mm and not exceeding 1000 mm: 1.2 m
- Pipelines over 1000 mm: 1.8 m.

G. Field Testing: General

G.1 All items for testing, including pressure gauges, instruments and water shall be provided on site before testing commences

G.2 Tests shall be carried out in the presence of the Engineer.

G.3 Fittings shall be permanently anchored before testing with all joints left exposed for checking.

G.4 Test sections shall be limited to runs of not more than 500 metres.

G.5 Pressure lines shall be tested between valve chambers unless agreed otherwise by the Engineer.

G.6 Gravity sewers shall be tested in sections between manholes.

G.7 No testing shall be carried out against or through the pressure reducing valves. The setting of the pressure reducing valves shall not be changed for testing purposes.

G.8 Test plugs shall be secured at the end of the main by struts.

G.9 Testing against a closed valve shall not be permitted unless agreed to by the Engineer.

G.10 Pressure shall be applied by a manually operated test pump or, in the case of large diameter mains, by a power driven test pump, if approved by the Engineer.

G.11 The Contractor shall examine exposed joints and repair all visible leaks.

G.12 Should a test fail, the Contractor shall locate all leaks and replace or make good defective pipes or replace and make good faulty joints as necessary. The main shall then be retested.

G.13 The Contractor shall prepare and maintain test records in a format approved by the Engineer. Original copies of the test record shall be presented to the Engineer immediately after completion of the test.

G.14 Hydrostatic tests on pressure lines shall be carried out whilst pipelines are partially backfilled.

G.15 Non-pressure lines not exceeding 1000 mm diameter shall be air tested before backfilling and hydrostatically tested after backfilling.

G.16 Non-pressure lines over 1000 mm diameter shall be visually inspection tested from the inside. All joints shall be individually hydraulically tested.

G.17 Infiltration tests shall be carried out on non-pressure lines where the crowns of pipes at the highest section under testing are more than 1.2 m below the water table.

H. Hydrostatic Testing of Pressure Pipelines

H.1 For hydrostatic testing, pipes shall be slowly filled with water from the lowest point. Power-driven pumps shall not be used unless indicated on the Drawings or approved by the Engineer.

H.2 Absorbent pipes shall be filled with water and allow to stand for at least 24 hours to allow complete absorption prior to hydrostatic testing.

H.3 Entrapped air in the pipelines shall be bled before pressurizing.

H.4 Pressurizing shall to continue until the specified test pressure is reached in the lowest part of the section under test. Entrapped air shall be bled while raising the pressure.

H.5 The test pressure shall be maintained for the specified test duration with pumping stopped.

H.6 The pipeline under test shall be repressurized to the original test pressure and the respective volumes of water pumped recorded.

H.7 The pipeline will be deemed to have failed the test if:

- Visible leaks are detected, regardless of leakage being within specified limits,
- The volume of water lost during period when pumping was stopped exceeds allowable leakage levels.

H.8 Test pressures shall be 1.5 times the maximum sustained pressure, minimum 13.5 kg/cm^2 unless otherwise specified on the Drawings or agreed by the Engineer.

H.9 The test period shall be 2 hours.

H.10 The allowable leakage shall be 0.1 litre/mm diameter/km length/day/30m of applied pressure.

I. Hydrostatic Testing of Non-Pressure Pipelines

I.1 The procedure for hydrostatic testing of non-pressure pipelines shall be as described for pressure pipelines.

I.2 The test pressure shall be a 1.0 metre head of water above the pipe soffit at the highest point in the section under test and not greater than a 6 metre head of water at the lowest point. If the maximum head is exceeded then the section shall be tested in stages.

I.3 The test period shall be 30 minutes.

I.4 The allowable leakage shall be 0.02 litres/linear metre/metre diameter/30 minutes.

J. Air Testing of Pipelines

J.1 Testing shall be carried out in accordance with BS EN 752-4. The section under test shall be sealed at both ends with a leakproof plug.

J.2 Pressure shall be applied by a hand pump or other method approved by the Engineer until a pressure of 3 psi (0.2 bar) head of water is indicated on a U-tube connected to the system.

J.3 Without further pumping the pressure shall not fall to less than 1 psi (0.66 bar) after a period of 10 minutes.

J.4 If the air test is not conclusive and no leakage can be traced by an external application of soapy water to all sealing areas, then hydrostatic testing shall be carried out.

K. Infiltration Test for Gravity Pipes

K.1 Infiltration testing shall be carried out after total backfilling of the length under test.

K.2 All inlets to system shall be plugged with an airtight seal prior to testing.

K.3 Residual flow shall be measured by a method approved by the Engineer

K.4 Infiltration limits: the following limits are not to be exceeded:

- Pipelines not exceeding 700 mm: 0.02 litres/hour/100 metres/mm diameter
- Pipelines over 700 mm: 0.03 liters/hour/100 metres/mm diameter.

K.5 Tests shall be deemed to have failed if allowable infiltration water volumes are exceeded. The source of excessive infiltration shall be located by traversing lights and mirrors, inflated rubber plugs or other method approved by the Engineer and made good to the satisfaction of the Engineer. Tests shall be repeated until successful.

L. Visual Inspection Tests

L.1 Visual inspection tests shall be carried out after backfilling of the section to be tested has been completed.

L.2 The length to be visually tested at one time shall be three full-length pipes unless otherwise agreed with the Engineer.

L.3 Rubber tyred bogies which do not damage the linings of pipes and an adequate supply of electric lamps shall be used to carry out the tests.

L.4 Joints shall be checked by feelers to ensure rubber rings are correctly located.

L.5 Pipes shall be checked for visible cracks.

M. Hydraulic Individual Joint Test for Pipes Exceeding 1000 mm

Testing shall be carried out in accordance with BS 5886:1980 (ISO 4483:1979), Type 2 testing after backfilling. Joints shall be pressurized to 2 bars and repressurized to 2 bars after 2 minutes. After a further 5 minutes no pressure drop shall be observed or the test shall be deemed to have failed.

N. Deflection Tests for GRP Pipes

N.1 Deflection tests for GRP pipes shall be carried out in 3 stages as detailed below. Deflections shall be measured at the spigot ends, at mid points and at socket ends:

- **Stage 1**: at completion of primary backfill (maximum allowable deflection 0.5%).
- **Stage 2**: at final backfill (maximum allowable deflection 2.5%).
- **Stage 3**: six months after final backfill (maximum allowable deflection 4.0%).

N.2 Pipes not passing the deflection tests at stage 2 or stage 3 shall be removed and replaced.

O. Flushing and Disinfection of Water Mains

O.1 Flushing and Disinfection of Water Mains shall be carried out in accordance with AWWA C651.

O.2 The Contractor shall provide all necessary equipment, gauges, temporary connections, chlorine and water needed for flushing and disinfection.

O.3 Water mains shall be flushed and disinfected in sections as directed by the Engineer.

O.4 Washout valves and fire hydrants shall be used to drain flushing and disinfecting water.

O.5 Before commencing disinfection, mains shall be flushed until all effluent and debris has been removed and the water is clean.

O.6 Mains shall be disinfected with chlorinated water, solutions of calcium hypochlorite or sodium hypochlorite as agreed with the Engineer.

O.7 Initial dosing of the disinfecting agent shall be 40-50 ppm.

O.8 The contact period shall be 24 hours.

O.9 Residual chlorine shall be measured by orthotolidin testing. Residual chlorine shall not to be less than 5 ppm or the dosing is to be repeated as directed by the Engineer.

O.11 After disinfection has been approved by the Engineer, the network shall be flushed with potable water until the chlorine concentration in the water leaving the main is less than 1 ppm.

O.12 Bacteriological tests shall be carried out in accordance with AWWA C651, Section 9. The number of samples to be taken shall be one per 1 km of main feeder and one per 0.25 km of distribution line.

O.13 Flushing and disinfection shall be carried out after cutting into existing main: in accordance with AWWA C651, Section 11.

P. Field Protection and Coating

P.1 Polyethylene encasement for iron pipes shall be in accordance with ANSI/AWWA C105, Section 4.1 minimum thickness 200 microns and/or in accordance with the manufacturer's instructions.

P.2 Metal joints to patented detachable and flexible joints and flanged connections shall be protected with mastic compound and protective tape in accordance with the manufacturer's instructions. Minimum overlap shall be 55%. All folds and irregularities shall be pressed out.

Q. Water Supply House Connections

Q.1 Locations of tappings shall be agreed with the Engineer before starting work on construction.

Q.2 Connections shall be programmed to follow closely construction of the main network.

Q.3 Ferrule cocks shall be drilled, threaded and taped in accordance with the manufacturer's instructions.

Q4 House connections shall be excavated, installed, laid and backfilled in the same manner as the main network.

Q.5 House connections shall be tested with the main network but testing shall exclude water meters.

Q.6 Accurate records of locations of house connections to the mains network shall be maintained by the Contractor. Record details shall include the following:

- Diameter
- Length
- Location
- Position of stop valves

Q.7 The Contractor keep records in a survey log book in a format approved by the Engineer. Survey log books shall be made available for inspection by the Engineer and handed to the Employer on completion. Survey log books shall include sketches and tables and three bound copies shall be produced for the Employer.

R. Sewer House Connections

R.1 The Contractor shall agree the location and invert levels of sewer house connections with the Engineer before starting construction.

R.2 The Contractor shall programme connections to follow closely on from the construction of sewers.

R.3 Connection to sewers shall be at manholes. Connections to T or Y junctions shall only be permitted if shown on the Drawings or if approved by the Engineer.

R.4 Connections shall be laid at a minimum grade of 20 per 1000 unless otherwise approved by the Engineer.

R.5 Sewer house connections shall be installed, laid and tested using the same methods as for main sewers.

R.6 The Contractor shall maintain accurate records of locations of connections to main sewers that include the following:

- Connection number
- Type of connection
- Pipe diameter
- Downstream manhole numbers
- Distance from manholes
- Positions (left or right) when facing upstream of street sewers
- Distance from the sewer centre line to the end lateral
- Invert of street sewer
- Lateral invert at end point
- Number and type of inspection chambers
- Cover type
- Location, description and elevation of obstructions and method of protection.

R.7 The Contractor shall keep records of sewer house connections in a survey log book, made available for inspection and handed to the Employer on completion. The survey log books shall include sketches and tables in a format approved by the Engineer and three bound copies shall be provided for the Employer.

S. Cleaning and Inspection of Sewers

S.1 Sewer pipelines shall be cleared of silt and debris after backfilling of pipe trenches and completion of manholes, hatch boxes and the like but before surfaces are permanently reinstated and made ready for inspection by the Engineer.

S.2 Pipelines of 700 mm diameter and over are to be inspected from the inside and when necessary a suitable trolley is to be provided for this purpose.

S.3 Pipelines less than 700 mm diameter and larger pipelines which cannot be inspected from the inside shall be inspected by passing a cylinder of a diameter 25 mm less than the internal diameter of the pipe and a length of not less than the internal diameter of the pipe through each pipeline.

8.02.4 MEASUREMENT

A. Earthworks

Measurement and payment for trench excavation and backfilling shall be made in accordance with the provisions of Section 2.10 of Division 2: Earthworks.

B. Pipelines

B.1 Pressure pipes shall be paid for per linear meter measured as a straight line between the centres of consecutive coupling sections. The distance between the two centres of the couplings on both sides of any fitting or valve shall be included as pipe length. No allowance will be made for cut ends and waste. No separate payments for any in-line fitting shall be made and the costs shall be deemed to be included in the rate for pipelines.

For gravity networks, pipes shall be paid for per linear metre measured as a straight line between the inside edges of manholes plus 20 cm inside the manhole from each side. No allowance shall be made for cut ends and waste.

B.2 Rates for pipes shall include for the following:

1) Staking out, field surveying and preparation of shop drawings,
2) Pipes, couplings and fittings,
3) Appropriate fittings and/or couplings for connecting to adjacent pipe or fitting including flanged fittings connecting to socket ended pipes,
4) Additional self restrained coupling sections adjacent to bends.
5) Bolts, nuts, gaskets and the like for flanged fittings,
6) Transportation and hauling about the Site, loading, unloading and lowering materials in the trench,
7) Lubricating agent used for assembling the pipe sections,
8) Cutting, machining, chamfering, etc. of standard length pipes,
9) Assembling the pipes and couplings
10) All work involved in connecting to new or existing fittings, valves, chambers, manholes and or structures as applicable.
11) Concrete thrust blocks including associated over excavation and anchors or additional self restrained coupling sections at bends. The concrete work shall include all items required for concrete work and concrete structures,
12) Testing in accordance with the specification,
13) Ancillary works and materials,
14) Flushing, cleaning, painting, lining and coating.
15) Disinfection of water supply pipes

B.3 Rates for pipe relocation shall include for the following:

1) Staking out, field surveying and preparation of Shop Drawings.
2) Appropriate fittings and/or couplings for connecting to adjacent pipes or fittings including flanged fittings connecting to socket- ended pipes.
3) Additional self-restrained coupling sections adjacent to bends.
4) Bolts, nuts, gaskets and others for flanged fittings.
5) Transportation and hauling about the Site, loading, unloading and lowering materials in the trench.
6) Lubricating agent used for assembling the pipe sections.
7) Cutting, machining, chamfering, etc. of standard length pipes.
8) Assembling the pipes and couplings and connecting to fittings and valves, or chambers, manholes and or structures as applicable.
9) Concrete thrust blocks including associated over excavation and anchors or additional self restrained coupling sections at bends. The concrete work shall include all items required for Concrete Work and Concrete Structures.
10) Testing as per specification.
11) Ancillary works and materials.
12) Flushing, cleaning painting, lining and coating.
13) Disinfection of water supply pipes.
14) Draining, stopping and sealing ends of redundant pipes

C. House Connections

C.1 Potable water house and sewer connections shall be paid per connection installed.

C.2 Rates for house connections for water supplies shall include:

1) Supply and installation of all materials including pipes, accessories and fittings, extension spindle, water service unit box and cover.
2) Supply of stopcocks and saddles on mains (tapping collar, elbows, tees, caps, valves).
3) Excavation, bedding and backfilling, concrete works, thrust block, reinstatement
4) Installation and connection to new network and to the service box, or to the existing service connection, and testing.
5) Coordination with the Engineer in collaboration with water authority offices and bearing of all cost associated with their requirements and procedures for maintaining uninterrupted service.

C.3 Rates for sewer connections shall include:

1) Supply and installation of all materials including pipes, fittings or specials.
2) Excavation, bedding, backfilling concrete works and reinstatement.
3) Connection to adjacent inspection chamber or to existing building discharge line and to the collection network using all necessary fittings and machining required to facilitate connection.
4) Installation, testing and commissioning.

PAY ITEMS	**UNIT OF MEASUREMENT**
(8.2.1) Concrete Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.2) Ductile Iron Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.3) UPVC Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.4) Steel Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.5) GRP Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.6) Realignment of Water Supply Pipes (*type and size*)	Linear Metre (m)
(8.2.7) Realignment of Sewer Pipes (*specify type and size*)	Linear Metre (m)
(8.2.8) Water service connection	Number (No)
(8.2.8) Sewer service connection	Number (No)

SECTION 8.03 VALVES AND ACCESSORIES

8.03.1 SCOPE

The work covered in this section includes the furnishing of all materials, construction, installation and completion of valves, sluices, sprinklers, hydrants, taps and meters for water supply and drainage.

8.03.2 MATERIALS

8.03.2.1 Valves

A. Ductile Iron Gate Valves

A.1 Gate valves for pipes of size 50 mm and smaller shall be supplied in accordance with BS 5154:1991 with inside screws, solid wedges, rising stems and screwed bonnets.

A.2 Gate valves for pipes of size 65 mm and larger shall be supplied in accordance with BS 5163:2004, with inside screws, solid wedges, resilient seated for valves 350 mm and smaller and metal seated for valves 400 mm and larger, bolted bonnets, non-rising stem types, suitable for NP 16 for water supply networks.

A.3 Materials for component parts from basic or alternative materials shall be as listed in BS 5163:2004 and BS 5154:1991.

A.4 End connections for pipe sizes 50 mm and smaller shall be screwed ends in accordance with BS 21:1985.

A.5 End connections for pipe sizes 65 mm and larger shall be flanged end connection in accordance with BS EN 1092-2:1997.

A.6 End connections shall be as shown on the Drawings and/or as described in the Bill of Quantities. Plain end connections shall be machined to suit joints specified for adjoining pipes.

A.7 Valves larger than 400 mm diameter shall have spur gear drives operated by removable keys. Valves smaller than 400 mm shall be operated by handwheels.

A.8 Factory protection: casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar in accordance with to BS 4164:2002 or bitumen to BS 3416:1991. The minimum thickness of the applied coat shall be 250 microns.

B. Butterfly Valves: Ductile Iron

B.1 Butterfly valves shall be manufactured in accordance with BS EN 593:2004 double flanged with resilient seating, for horizontal use and suitable for NP 16.

B.2 Ductile iron butterfly valves shall be used for pipe sizes of 350 mm and larger.

B.3 Material for component parts shall be in accordance with BS EN 593:2004 Table 3.

B.4 End connections shall be flanged in accordance with BS EN 1092-2:1997.

B.5 The maximum shut off pressure against which valves are operated by hand wheel shall be 15 kg/cm^2.

B.6 Factory protection: Casting surfaces are to be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coatings shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 250 microns.

C. Check Valves

C.1 Check valves shall be manufactured in accordance with BS EN 12334:2001, swing, straight, for horizontal use and suitable for working pressure of 16 bars.

C.2 Component parts shall be manufactured from ductile iron and basic materials listed in BS EN 12334:2001 Table 5, under 'copper alloy faced' column.

C.3 Seating or facing rings shall be renewable. An arrow showing the direction of flow shall be visible from the outside and cast integral with the valve housing.

C.4 End connections shall either be flanged to BS EN 1092-2:1997 or screw ended to BS 21:1985 to suit joints specified for adjoining pipes.

C.5 Factory Protection: Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 200 microns.

D. Air Valves

D.1 Air Valves for Water and Irrigation Mains

D.1.1 Air valves for water and irrigation mains shall have cast iron bodies and bolted covers to BS EN 1561:1997 grade 14 minimum, rubber outlet seats, plastic or ebonite balls, forged bronze screws and guides for balls acting under pressure. Valves shall be dynamic types with no possibility of balls being drawn into orifice due to high air velocities. Valves shall be factory tested to 1-1/2 times working pressure and factory coated with coal tar or bituminous coatings to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 250 microns.

D.1.2 Single air valves, Type I (or air vacuum valve) for releasing or admitting air during filling or emptying of pipes or Type II (or air release valve) for automatically releasing, under pressure, accumulated air at summits of mains: Air valves larger than 50 mm are to be flanged to BS EN 1092-2:1997 and shall have nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicator and locking thumb screws. Air valves 50 mm and smaller shall have B.S.P. threads with brass or gun metal male screwed stop valves. Valves shall be suitable for working pressures up to NP16.

D.1.3 Double air valves (combination air valves) shall have the large orifice area equal to or greater than the valve inlet. Valves shall be fitted with nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicators and locking thumb screws. Valves shall be flanged to BS EN 1092-2:1997 and suitable for working pressures up to NP16.

E. Ball Valves

Ball valves 50 mm and under shall be full port, 2-piece construction, lever operated with bronze bodies and stems, chrome-plated brass balls, replaceable PTFE seats and packing, plastic coated steel handles, threaded end connections for steel piping and copper compression or solder end connections for copper piping.

F. Globe Valves

F.1 Globe valves shall be manufactured to ASTM A48 grade 30B with valve discs to ASTM A276 type 430, valve seats to ASTM A276 type 420 and stems to ASTM A276 type 403. Valves shall be suitable for a working pressure of 16 Bar.

F.2 Globe valves shall have non-rising stems, straight pattern with flanged connections.

F.3 Valves shall be class PN 10 and 16, cast iron with stainless steel trim.

F.4 Manually operated valves shall have hammer type handwheels and electrically operated valves shall have motor actuators.

G. Underground Stop Valves

G.1 Underground stop valves shall be manufactured in accordance with BS 5433:1976 with crutch or square heads.

G.2 Unless otherwise specified valve bodies, leads, glands, spindles and washer plate square heads shall be gunmetal to BS EN 1982:1999 - LG2, seating washers shall be vulcanized synthetic rubber to BS 3457:1973 Clause 6 and head sealing '0' rings shall be in accordance with BS EN 681.

G.3 End connections inlets and outlets of valves shall be internally threaded to BS EN ISO 228 to fit threaded specials to polyethylene pipe.

H. Float Valves

H.1 Float valves shall be globes with two operating chambers, sealed through piston discs.

H.2 Float valves shall be the mechanically compensating, controlling the flow to tanks by modulating in direct ratio to the minimum fall in water level. Control shall be through mechanically operated, three-position, four-way valves. Moving four-way valve controls in one direction shall open valves and moving levers in other direction shall close out valves. When the lever is moved to the centre, valves shall throttle into an intermediate position.

H.3 Valve positioning controls consists of float operated linkage mechanisms for remote mounting feeding water level changes back to main valves through low friction, flexible push-pull cables supplied by the same manufacturer.

H.4 Valve operating controls consists of secondary linkages with the mechanism functioning off common levers connected to both the main valve position indicator rods, control valve position indicator rods and control valve operating levers. Minute changes in water level shall be transmitted through push-pull cables to three-position, four-way control valves.

H.5 Valves shall be constructed with cast iron bodies to ASTM A 126, bronze valve trim and valve operating mechanisms to ASTM B62 and all stainless steel valve floats and pilots.
Valves shall be protected with an internal coating of epoxy to a thickness of 120 microns and external coating of epoxy and nickel plating to a thickness of 120 microns.

I. Air Valves for Pressurised Sewer Mains

I.1. Valves shall be manufactured with cast iron bodies, covers and baffles to BS EN 1561, Grade 14, stainless steel float and float guide, Buna-N seats or needles and nylon internal linkages. Air valves shall have long float stems and bodies to keep valve operating mechanisms free from contact with sewage by maintaining an air gap between the mechanisms and the waste media. Floats shall hang freely in the centre of valve bodies with 12 mm clearance all around to prevent large solids getting above the float. Valves shall be fitted with blow off valves, quick disconnect couplings and minimum 2.0 m of hose to permit backflushing without dismantling valves. Valves shall be factory tested to 1.5 times working pressure and factory coated with coal tar bituminous coatings to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coating shall be 250 microns.

I.2. Single air valves shall be specified as Type I (air vacuum valve) for releasing or admitting air during filling or emptying of pipes or Type II (air release valve) for automatically releasing, under pressure, accumulated air at summits of mains. Air valves 50 mm and smaller shall have screwed inlet to B.S.P. thread with gunmetal male screwed stop valve. Air valves larger than 50 mm shall be flanged to BS EN 1092 and have nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicators and locking thumb screws. Valves shall be suitable for working pressures of up to NP10.

I.3. Double air valves (or combination air valves) shall be assemblies of an air vacuum and an air release valve. Valves shall be suitable for working pressures up to NP16.

J. Sluice Gates

J.1 Sluice gates shall be manufactured in accordance with AWWA C501, with rising stems, flat backs for bolting to wall, suitable for 6 metre seating pressure and 4 metre off-seating pressure, standard conventional closures and rectangular or circular apertures.

J.2 Unless otherwise specified on the Drawings slice gates shall be manufactured from any materials listed in Section 2 of AWWA C501 except materials identified as being subject to de-zincification or de-aluminumization.

J.3 Sluice gates shall be operated by floor pillars with gear boxes. The maximum operating head from the water surface to the gate centreline shall be 6 metres.

J.4 A leakage test to meet the requirements of Section 6.3 of AWWA C501 shall be carried out on all sluice gates.

J.5 Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1999 respectively. The minimum coating thickness of coat shall be 250 microns.

K. Flap Valves

K.1 Flap valves shall be flange mounted and designed for use on end closures to prevent the entrance of backwater. The seating plane shall have a 10 degree inclination.

K.2 Flap valves shall be manufactured with cast iron bodies and covers, bronze seat faces, bronze hinge pins and spring pins, cast iron follow rings and plated steel ring draw bolts. Materials subject to de-zincification or de-aluminumization shall not be used.

K.3 If end connections are specified or proposed as flange mounted, flanges shall be manufactured in accordance with BS EN 1092.

K.4 Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coatings shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1999 respectively. The minimum coating thickness shall be 250 microns.

L. Penstocks

L.1 Penstock doors, wedge support beams, frames, guides, frame extensions, headstocks and bridge pieces shall be cast iron of minimum grade 220 to BS EN 1561:1997. Doors and frames shall be fitted with renewable seatings of zinc free bronze.

L.2 Spindles shall be manufactured from stainless steel 431S29 (BS 970) or similar approved material.

L.3 Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adaptor incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (BS 970) steel. Intermediate bearing supports or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE unless otherwise agreed with the Engineer.

L.4 Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

L.5 Where necessary, support guide bushes shall be fitted at the base of the pedestal.

L.6 The pedestal height shall be such that the handwheel is approximately 1 metre above the operation floor level.

L.7 Clear polycarbonate covers shall be provided for all rising spindles to fully enclose them when in the fully raised position.

L.8 All penstocks shall be designed and installed so that the maximum working pressure acts in a seating direction on the gate.

L.9 Gates and frames shall be sufficiently rigid to withstand twice the maximum working pressure and any eccentric pressures created by the tightening of the anchor bolts during installation. All penstock frames shall have a spigot back.

L.10 The frame shall be designed to ensure that the gate is supported over not less than two thirds of its depth when the gate is fully raised.

L.11 Penstocks shall be of the rising spindle type unless otherwise specified. The spindles shall be of adequate size to avoid buckling under load.

L.12 All spindle nuts shall be self aligning and their length shall be not less than twice the spindle diameter.

L.13 The top part of the penstock frame shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted. The penstocks shall be fitted with matching wedges on doors and guides, the wedges shall be fitted with renewable seatings of zinc free bronze. Under no circumstances shall wedges be fitted to the bottom or lower sections of the penstock doors. The wedges shall be adjustable with stainless steel adjusting screws and shall be readily removable.

L.14 On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the doors. The rubber shall be suitable for the application and of a type approved by the Engineer.

L.15 The doors shall have lifting eyes cast in, or eye bolts of sufficient size to permit the lifting of the door against the seating pressure.

L.16 Where extended spindles installations require to be operated at an elevated floor level, spindle guides or guide brackets shall be provided close to the floor level.

L.17 Where penstocks are required to be operated by tee keys, spindle caps shall be fitted. The caps shall be drilled and each provided with nuts and bolts for securing to the spindle which shall also be drilled. Where caps are fitted they shall be supplied complete with operating tee keys.

L.18 All penstocks shall be provided with headstocks except where the handwheels can be mounted on the penstock frames. For penstocks of 300 mm ND. (square or circular) and above and for all motorized and actuator operated penstocks, unless otherwise stated, thrust tubes shall be provided between the penstocks frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle quid plates.

L.19 Headstocks and foot brackets shall be provided for non-rising spindle penstocks unless otherwise detailed in the Drawings. Guide brackets shall be provided where necessary. Non-rising spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstocks directly to the penstock frames. Where headstocks are required on non-ring spindle installations they shall incorporate a penstock position indicator.

8.03.2.2 Irrigation Works

A. Electric Remote Control Valves

A.1 Electric remote control valves shall be normally closed 24 V AC 50/60 cycle solenoid actuated globes of a balanced pressure diaphragm design. The valve operating pressure range shall be between 1.5 and 14 bars.

A.2 Valve bodies and bonnets shall be constructed of heavy-duty glass-filled UV-resistant nylon and have stainless steel studs and flange nuts. The diaphragm shall be manufactured from nylon reinforced rubber.

A.3 The valves shall have manual open/close controls (internal bleed) for manual operation of valves without electrically energizing the solenoids.

A.4 The valves shall have brass flow control stems for accurate manual regulation and/or shut off of outlet flows.

A.5 All internal valve parts shall be removable through the tops of valves without disturbing the valve installation.

B. Electric Remote Control Valves with Pressure Regulation

B.1 Electric remote control valves shall have pressure regulating modules capable of regulating outlet pressures of between 1 and 7 bar.

B.2 Modules shall have adjusting screws for setting pressures and Schrader valve connections for monitoring pressure. Pressures shall be adjustable from the pressure regulating modules when valves are manually bled.

C. Pop-Up Spray Sprinkler

C.1 Pop up spray sprinklers shall be fixed, non-rotating spray or stream spray types adaptable for full circle, part circle or strip wetting patterns and suitable for installation on pop-up mechanisms. Spray heads shall have built in check valves and pressure regulated stems.

C.2 The sprinkler body, stem, nozzle, and screen shall be constructed of heavy duty, ultra-violet resistant plastic with a heavy-duty stainless steel retract spring.

C.3 Spray heads shall retract flush with the finished ground level when not in operation. When spraying, the net pop-up height shall be 150 mm from the finished ground level.

C.4 Pop up spray sprinklers shall meet the requirements of discharge and spray radius as specified on the Drawings for the given nozzle pressure. Each sprinkler shall have a matched precipitation rate nozzle with an adjusting screw capable of regulating the radius of flow.

C.5 The Contractor shall provide test results carried out at the factory substantiating required performance (discharge and radius of throw at prescribed operating pressure and height above ground) and giving the actual precipitation rate and its uniformity as obtained for uniformity test carried out using catch cans.

D. Pop-Up Rotor Sprinkler

D.1 Full or part circle pop-up rotor sprinkler shall have a single nozzle. The part circle sprinkler shall have adjustable arc coverage from 25° to 360°. Each sprinkler shall have a built in check valve and pressure regulated stem.

D.2 Each sprinkler body, stem, nozzle, and screen shall be constructed of heavy duty, ultra-violet resistant plastic, with a heavy duty stainless steel retract spring.

D.3 Sprinkler heads shall retract flush with the finished ground level when not in operation. When operating, the net pop-up height shall be 100 mm above finished ground level.

D.4 Sprinklers shall meet the requirements for discharge, radius and rotation angle as specified on the Drawings for the given nozzle pressure. The sprinkler shall have a matched precipitation rate nozzle, with an adjusting screw capable of regulating the radius and the flow.

D.5 The Contractor shall provide test results carried out at the factory substantiating the required performance (discharge and radius of throw at prescribed operating pressure and height above ground) and giving actual precipitation rates and uniformity as carried out using catch cans.

E. Bubblers

E.1 Bubblers shall be of the pressure compensating type with full circle umbrellas or trickle discharge and inlet screens.

E.2 Bubblers shall be manufactured from durable ultraviolet- resistant plastic.

E.3 Bubblers shall operate at a constant flow discharge over a pressure range as specified on the Drawings.

F. Emitters

F.1 Emitters shall be the pressure compensating type with single outlets.

F.2 Emitters shall have self piercing inlet barbs constructed of durable ultraviolet- resistant plastic.

F.3 Each emitter shall have a self flushing action to minimize clogging and shall operate at a constant flow discharge over a pressure range as specified on the Drawings.

G Quick Coupling Valves

G.1 Quick coupling valves shall be the two piece type.

G.2 The valve body shall be constructed of heavy cast brass.

G.3 Covers shall be manufactured from durable, self-sealing rubber.

G.4 Valves shall be opened and closed by brass keys supplied by the manufacturer having 25 mm male top pipe threads at inlets and 19 mm female top pipe threads at outlets. Valve throats shall have keyways with indented positions for regulating water flow. Operating keys shall be supplied at the rate of 1 per 5 couplings installed or fraction thereof.

H. Backflow Preventers

H.1 Backflow preventers shall be of the reduced pressure type and be installed in the locations shown on the Drawings.

H.2 Backflow preventers shall meet the performance requirements of AWWA C 511.

H.3 Backflow preventers up to 75 mm in size shall have machined cast bronze body construction and up to 150 mm in size shall have a cast iron body construction and with epoxy coated stainless steel and/or brass internal parts, stainless steel flange bolts and durable, tight-seating rubber check valve assemblies.

H.4 Backflow preventers shall be suitable for supply pressures of up to 1.2 MN/ m^2 and for water temperatures of up to 44 ^{O}C. The operating range for flow and pressure loss shall be as shown on the Drawings.

H.5 The backflow preventer assembly shall consist of a pressure differential relief valve located between two positive seating check valves. The relief valve shall contain a separate portal for venting and water discharge, when the valve is fully open.

H.6 The backflow assembly shall include 2 gate valves for isolating units and 3 test cocks for testing the device to ensure proper operation.

H.7 Backflow preventers shall be designed for inline servicing.

I. Isolating Valve

I.1 Gate valves shall have brass bodies and bonnets. Valve stems and seats shall be removable from the valve body without disconnecting the body from piping network. Valves shall be PN 20 and have female threaded sockets.

J. Air and Vacuum Relief Valves

J.1 The air and vacuum relief valves shall be of the orifice type and non-corrosive construction. The valve shall be rated at 10 bar working pressure. The floating balls shall be of vulcanized rubber and shall withstand a temperature of 60°C. Air vacuum assemblies shall be installed at high points to allow air and vacuums to be expelled.

K. Inline Filter

K.1 The in-line Wye filter shall be constructed specifically for low flow irrigation applications. The filter body shall be constructed of heavy duty glass filled UV resistant nylon material providing a pressure rating of not less than 10 Bar. The filter element shall be constructed of a durable polyester fabric attached to a polypropylene frame

K.2 The standard 200 mesh screen shall be serviceable for cleaning purposes by unscrewing the cap from the body and removing the filter element. Colour coded replaceable filter elements of 150 mesh (blue) and 200 mesh (white) shall be available from the manufacturer of the inline filter. The body shall have a 20 or 25 mm female threaded inlet and outlet. The design shall be of a compact "Y" body and cap configuration.

L. Pumps and Pumping Stations

L.1 Submersible Motor-Pump Set

L.1.1 Operation

Horizontal submersible pumps shall be located in reservoirs. The operation of this pump shall be automatically controlled by the system controller during irrigation. They shall be started daily at a predefined time and shall be stopped when the water level in the reservoir reaches the water sensor levels.

L.1.2 Electric Motor

L.1.2.1 Type

Electric motors for submersible pumps shall be supplied in accordance with the following:

- Wet type submersible motor
- 3 phase – 50Hz – 380V – Asynchronous

- Horizontal axis – IP68 Class Protection

L.1.2.2 Power

The motor power unit shall exceed by 20% the required power taking into consideration the losses due to cables and wiring.

L.1.2.3 Maximum Rotation Speed

The maximum rotation speed of pump motors shall be 3000 rpm.

L.1.2.4 Output and Output Factor

When the motor's power is at 75 % of the nominal power, the output shall be at least 80% and the output factor at least 0.8.

L.1.2.5 Mechanical Couples

The Contractor shall submit details of the various couples (nominal couple, starting couple, maximum couple and other data as applicable) selected by both the pump and the motor manufacturer to the Engineer for approval.

L.1.2.6 Technical Specifications for Manufacturers

Electric motors shall be manufactured in accordance with the following:

- Wet stator windings with special PVC insulated copper conductors.
- Temperature rise limited to class B.
- Insulation: Minimum Class F
- Transmission shaft made from stainless steel with a 12% minimum chrome content.
- Protection degree IP68
- Bearings shall be the self lubricating type, designed to ensure proper alignment of the rotor and shaft.
- Construction standards: NFC 51-165 & NFC 51-104.
- Motors shall be fitted with expansion diaphragms.
- Coupling: rigid sleeve coupling.
- Cables in continuous lengths from the inside motor connections to motor control panels.
- Paint finish: seawater resistant synthetic resin.
- Submersible pump sets shall be fitted with cooling shrouds.

L.1.3 Pumps

L.1.3.1 Type

Pumps shall be centrifugal or helicoid centrifugal multiple stages, for horizontal installation and handling clean, cold water.

L.1.3.2 Rotation Speed

The pump rotation speed shall be the same as for the electric motor rotation speed and at 3000 turn/min as a maximum.

L.1.3.3 Output

Pump outputs shall not be less than 70% in normal conditions of use.

L.1.3.4 Working Temperature

Pumps shall be capable of operating with a water temperature of between 10° C and 25° C

L.1.3.5 Technical Specifications for Manufacturers

Pumps shall be manufactured in accordance with the following

- Turbines shall be the closed or half closed type, made of zinc- free bronze.
- Pump bodies shall be manufactured from bronze or cast iron, internally enamelled,
- The manufacturer shall specify the minimum head loss through friction for each pump.
- Transmission shafts shall be made of stainless steel with a high percentage of chrome (13% minimum).
- Bronze bearings shall be used.
- Lubrication shall occur with water circulating across the pump.
- Strainers shall be made of bronze or stainless steel.
- The pumps shall be coated with seawater resistant synthetic resin.
- Pumps shall be manufactured in accordance with BS EN 733:1995

L.1.4 Motor and Pump Assembly

L.1.4.1 The assembly between the electric motor and the pump shall follow the manufacturer's instructions. Submersible pump sets shall be equipped with non-return valves, fitted inside the pumps.

L.2 Borehole Pumps

L.2.1 Rising Columns

L.2.1.1 Borehole pump rising columns shall be manufactured from seamless steel and provided in section lengths not exceeding 3 meters with flanged joints or screwed couplings according to API5L grade B or equivalent. Rising columns shall allow for small deviations in borehole verticality. Cables and water level dip tubing shall be securely fixed to the rising column by straps or bands at approximately 2 metre intervals.

L.2.1.2 Rising columns shall be sufficient to take the stresses generated by the hanging weight of the pump, motor and rising column, the stresses produced by the water pressure together with any dynamic stresses which may occur under any circumstances including valve closure. Rising columns shall be protected at the factory both internally and externally against corrosion using a non toxic epoxy resin coating (300 μm minimum thickness) suitable for use with potable water.

L.2.2 Borehole Pump Headworks

L.2.2.1 A fabricated steel discharge head piece shall be provided at the top of each borehole to support the complete rising column and electro-submersible pumpset assembly, complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90° discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate to accommodate an air vent pipe, motor and control cables, water level dip tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination.

L.2.2.2 A 25mm diameter screwed removable plug with electrical contact tape shall be provided over the dip tubing for water level measurement. A stainless steel air vent pipe shall be fitted to the discharge head sealing plate, terminating in an insect-proof screen and arranged to prevent entry of rain or surface water.

L.2.3 Electric Panelboards

L.2.3.1 Panelboards shall be the dead-front type, enclosed metal, floor mounted (pedestal type), free standing, 600V class of service switchboards.

L.2.3.2 Panelboards shall be rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 2 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating in a colour approved by the Engineer.

L.2.3.3 Switchgear shall be vermin, dust and rodent proof, IP65 suitable for exposed outdoor installation.

L.2.3.4 Control and measuring instruments shall be installed on removable cover plates inside the panelboard.

L.2.3.5 Schematic and wiring diagram shall be provided, suitably located within the panelboard.

L.2.3.6 The panelboard shall be provided with 1 socket outlet, which shall be installed to facilitate connection of portable tools.

L.2.3.7 The panelboard shall be fitted with a demountable undrilled metal gland plate positioned at a low level but with adequate space for termination of cables, conduits, etc. The gland plates shall be efficiently earthed to the panel earthing system by a separate earthing conductor. The base of the panel shall be provided with removable plates of the split type to seal the cable/conduit entry cut-outs. The plates shall be positioned directly below the gland and base plate shall be of non-ferrous material. Panelboards shall be suitable for mounting on concrete plinths.

L.2.3.8 All foundation holes shall be at least 75 mm from any outside edge of the panel and at least 75 mm from any concrete edge to avoid break-out when tightening bolts.

L.2.3.9 Where multiple compartments are used, each compartment shall be provided with a full width access door.

L.2.3.10 All doors and covers shall have returned edges for rigidity and incorporate dust seals of flexible material secured in channel rebates. Covers exceeding 0.5m² in area shall be provided with a supporting lip within the lower edge or have lift-off hinges. All doors shall be supported on strong hinges of non-corrodible material and shall be secured by adjustable quarter-turn cams, operated by small tee handles incorporating key operated barrel locking facilities or flush locks with drive key inserts. Covers shall be secured by similar fastenings or captive bolts.

L.2.3.11 All additional fittings such as handles, hinge brackets and locks shall be to a black finish, polyamide moulding or epoxy coated metal.

L.2.4 Terminals

L.2.4.1 Terminal blocks shall be provided for the connection of cables.

L.2.4.2 Terminal blocks shall be arranged so that both terminals and wiring ends are readily accessible and have separate terminals provided for incoming and outgoing wires, together with insulated barriers between adjacent connections and transparent insulated covers. Blocks accommodated on common mounting rails shall have a foot designed to ensure a secure fit to the rail. Foot springs shall be of stainless steel and have a locking device fitted to prevent accidental release of the block.

L.2.4.3 Each terminal shall be labelled to correspond with the diagram of connections and terminal identification labels shall be attached to the fixed portion of the terminal blocks only. Terminals for intrinsically safe circuits shall be clearly segregated and coloured blue.

L.2.4.4 Terminals which may be live when the equipment is isolated from the mains supply shall be adequately shielded from accidental contact and be clearly identified and inscribed accordingly.

L.2.4.5 All terminal boards and terminal blocks shall provide a positive mechanical clamp type connection. Pinch screw type terminals shall not be used. Terminals for the connection of all external cabling shall be situated at least 100 mm from their respective gland plates or further if the cable size requires a greater distance for dressing.

L.2.5 Circuit Breakers

L.2.5.1 Moulded Case Circuit Breakers

Moulded case circuit breakers shall be of the quick make, quick break and trip-free type complying with BS EN 60947-4-1:2001 and shall have adjustable thermal magnetic trip units on each pole or an electronic trip unit.

L.2.5.2 Thermal-Magnetic Motor Circuit Breakers

Thermal-magnetic circuit breakers shall be of the quick make, quick break trip type complying with BS EN 60934:2001 and BS EN 60947-4-1:2001 standards and shall be complete with the following:

- An adjustable thermal overload protection with automatic temperature compensation between -20° C and +60° C for open mounting and -20° C and +40° C for closed mounting.
- An instantaneous protection against short-circuit with fixed threshold 13 times the rated current.
- A minimum of three auxiliary switches that indicate pole position and a minimum of one auxiliary switch for tripping.
- A shunt trip release for remote tripping.
- A counter that indicates the number of open/close or tripping operations of the circuit breaker for maintenance purposes.
- A visual indication of open/close/tripped condition.
- Circuit breakers shall be padlockable in the "OFF" position.

L.2.5.3 Miniature Circuit Breakers

Miniature circuit breakers shall be of the quick make, quick break and trip-free type complying with BS EN 60898:1991 Circuit breakers shall be complete with thermal/magnetic or magnetic/hydraulic releases. Multi-pole breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any pole will cause all poles to open simultaneously. Visual indications of open, close and trip conditions shall be provided. Circuit breakers shall be padlockable in the "OFF" position where specified.

L.2.5.4 Residual Current Circuit Breakers

Residual current circuit breakers shall be arranged to isolate each live conductor simultaneously within 30 milliseconds if the residual leakage current through the device exceeds 30mA. They shall be housed separately or incorporated into other composite enclosures, with provision for testing the tripping operation under earth leakage conditions by means of built-in resistors and push buttons and require manual resetting.

L.2.6 Motor Starters

L.2.6.1 General

Motor starters shall be housed in damp-proof and dustproof cubicles.

Each starter shall contain all the necessary equipment to control the circuit load and isolate it from the supply in the event of a fault and shall be equipped to comply with the following general requirements unless otherwise specified under the relevant starter duties.

For starting LV Motors direct on line, the starter shall be rated for intermittent duty class 0.3 (up to 30 operating cycles/hour) and utilization category AC3 in accordance with BS EN 60947:2001, or as otherwise specified.

The starters shall comply with BS EN 60947-4-1:2001 (Motor starters for voltages up to and including 1000V AC). The motor starter shall be of a rating to carry the full load current of its rated duty at its most severe load conditions. All starters shall be capable of carrying out at least the number of starts per hour at 100% full load torque.

Motor starter control circuitry shall be arranged to suit the motor drive.

Unless otherwise specified, 3-phase, 380V motors shall be provided with Direct-On-Line starters up to and including 5 KW rating.

The Contractor shall ensure adequate rating for operating under the relevant climatic conditions and demonstrate this to the Engineer's satisfaction.

The motor starter shall be of sufficient rating to carry the full load current of its rated duty at its most severe load conditions. Panel control circuits shall operate at 110/220 VAC single phase.

L.2.6.2 Contactors

Power contactors shall be to BS EN 60947-4-1:2001 and shall have the following characteristics:

- Rated insulation voltage: > 1000 V
- Rated Operational Voltage : 1000 V
- Rated breaking capacity : 10 times the rated current.
- Electrical life at rated current and 380 V : > 1 million cycles.

All contactors shall be of the air-break electro-magnetically held-on type. All contact pieces shall be readily replaceable and the necessary auxiliary contacts for control, indication and alarm shall be mounted in accessible positions and arranged in the same sequence on each contactor.

L.2.6.3 Protection

Each starter shall be provided with an adjustable motor over-load and single phase protection device suitable for the motor load and have adjustable trip and reset delays provided, together with manual local and remote resetting facilities. Ambient temperature compensation shall be provided where relevant. Other protection features shall be as specified relevant to the particular drive.

Protection devices shall be arranged to trip the load and initiate the fault indications specified and accept normal switching of load.

Where starters are fed directly from busbars or other systems having a high prospective fault level, suitably rated fuses or other means shall be provided within the starter to limit the fault let through to a value within the rating of the starter components. Protective overload devices shall be arranged to ensure that any such fault is cleared by such fuses and provide Type '2' coordinated protection to BS EN 60947-4-1:2001.

L.2.6.4 Star Delta Starters

Star Delta starters shall be of the closed transition "Wauchope" type, having starting resistors, mechanically and electrically interlocked Star and Delta contactors plus a timing relay in addition to DOL starter requirements, all rated for up to 10 starts per hour.

L.2.6.5 Auto-Transformer Starters

Auto transformer starters shall be of the closed transition "Korndorffer" type, having suitably rated mechanically and electrically interlocked "start" and "run" contactors plus a timing relay in addition to DOL starter requirements.

The auto transformer shall be oversized, Class H, air cooled with tappings provided at 50%, 65% and 80% of line voltage and be suitably rated for up to 10 starts per hour. The transformer shall be contained within the starter panel or may be installed in a separate enclosure.

Contactors shall be of the same type and rating. The current rating of the contactors shall be chosen 10% higher than required by the driving motor in utilization category AC3.

L.2.6.6 Motor Managers

Each motor shall be a self- monitoring unit with the following operating features:

- Select and change operating parameters.
- Select and modify setting values.
- Display values and modifications.
- Indicate faults.
- Test, e.g. verify the unit operation.
- Reset: Enable the unit after a trip.

Technical data:

- Operating temperature : -5°C to 60°C
- Storage temperature: -40°C to 60°C

- Climatic sensitivity: as per BS EN 60068-2-1:1993 and BS EN 60068-2-30:2005.
- Degree of protection: IP65
- Resistance to vibration: as per BS EN 60068-2-6:1995.
- Resistance to shock: as per BS EN 60068-2-27:1987.
- Noise emission and noise proof in accordance with EMC Standard.
- Power supply module shall be self-protected against short circuits.
- Data shall be retained in case of voltage supply failure.
- Fail-safe operation.
- Output relays (contacts) galvanically separated.

Protective functions:

- Thermal overload.
- Asymmetry.
- Overload.
- Rotor stalling during running and starting period.
- Underload
- Earth fault.
- Long starting (monitoring of starting time).
- Limited starts per hour.
- Short circuit.
- Thermistor (PTC) input.
- Phase sequence.
- Phase failure.
- Pt 100 input.

In addition to the protection brought by the motor manager, the submersible pumps shall be protected against overpressure and low water level (in the reservoir or in the borehole).

L.2.6.7 Control Circuits

The submersible pump in the reservoir shall be controlled by the pumping start relays of the sprinkler control system.

The submersible pump in the borehole shall be controlled by the water level inside the reservoir. It shall be stopped when the reservoir is full.

An ‘AUTO/MANUAL’ selector switch shall be provided to ensure manual control when needed.

All control circuits shall operate at not more than 110V and be derived from a double- wound, screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from one phase to neutral if available.

Fuses shall be provided on each primary and secondary supply and be clearly labelled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit and the mains supply must be isolated before opening the cubicle door but provision shall be made to re-energize the control circuit when the mains supply to the cubicle is isolated so that the operation of the control gear may be inspected without energizing the motor. The control circuit Normal/Test switch shall be mounted within the cubicle and arranged so that it is not possible to close the door with the switch in the 'Test' position.

Control selector switches fitted to the front of starters shall have matching operating handles which are clearly shaped to show the selected position. Specified function switches shall have key operated barrel locking devices in the handle, or be key-operated alone, with the key removable in each lockable position.

All fault conditions relevant to each mode of operation shall stop the drive and prevent it re-starting until the particular fault is cleared and individually reset; lock-out relays and a reset button shall be provided for any self-resetting devices such as excess torque switches etc.

Specified fault conditions shall be identified by separate indications on the starter. Volt-free contacts shall be provided and wired to terminals in each starter unit for remote signalling of all status indications specified. Minimum status indications shall be Auto Available/Unavailable and Running/Fault.

"Hours-run" meters shall be of the non-resettable cyclometer type indicator having a flush fascia and driven by a synchronous motor connected to show the hours (up to 99,999.9) run by the main motor. They shall incorporate a visible indication of operation but need not necessarily be of the same bezel size as the instruments.

All starters for motors of 3 kW and above shall have ammeters. Local 'running' indicator lamps shall be provided for loads less than 3 kW.

Control circuits shall be protected by appropriate fuses or circuit breakers.

L.2.7 Power Cables

L.2.7.1 Single Core PVC Insulated Cables

Unless otherwise specified, single conductor cables for wiring in conduit shall have annealed copper conductors, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC/E to IEC 60227, suitable for wet

locations and for conductor temperatures of 85 °C. Wires and cables are to be 450/750 V grade.

L.2.7.2 Multi-Core PVC Insulated Cables (0.6/1 kV)

Multi- core PVC insulated cables shall have annealed, copper conductors, insulated with PVC/E to IEC 60227, flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 85 °C, laid up, bedded with suitable filler and sheathed with PVC. Armoured cables shall have single layers of galvanized steel wire armour with PVC oversheathes. Cables shall comply with IEC 60502 and IEC 60811.

L.2.7.3 Single Core XLPE Insulated Feeder Cables (0.6/1 kV)

Single-core circular stranded annealed copper conductors shall be insulated with flame retardant, moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 °C and PVC over-sheaths. Armoured cables shall have taped bedding, single wire aluminium armour and PVC oversheathes.

L.2.7.4 Multi-Core XLPE Insulated Feeder Cables (0.6/1 kV)

Single core annealed copper conductors, XLPE insulated, for conductor temperatures of 90 °C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and PVC oversheathed, colour black. Armoured cables shall have a single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and oversheathed with PVC, coloured black. PVC oversheathes shall be type ST2 to IEC 60502.

L.2.8 Earthing Systems & Surge Protection

L.2.8.1 General

The earthing system shall consist of one or several rods. The resistance of the earthing system shall not exceed 5 Ohms. The Contractor shall install a sufficient number of rods to achieve this resistance value.

Each earthing rod shall consist of a copper-clad steel core, with a minimum diameter of 18 mm and a length of 2.5 m. The heads of the grounding rods shall be buried 500mm deep in the ground. A concrete manhole having a 500mm side shall be prepared for each earth terminal in order to facilitate maintenance operations and later reinforcement works utilizing additional elements if required to increase the earthing installation.

The manhole shall have a coloured plastic cover allowing permanent access.

The head of each earthing terminal shall be fitted with a sectioning bar allowing the isolation of this earthing element from the installation and the measurement of the ground resistance.

The connection of earthing cables to the earthing system shall be by sockets ensuring a good contact.

L.2.8.2 Earthing Conductors

Sections of earthing conductors for the various panel terminal and power supply circuits shall be as for the phase conductor of the corresponding circuits and not less than 2.5 mm².

Connections shall be carried out by permanent welding or screw clamping.

All insulated earthing conductors shall be yellow-green. This colour shall not be used for any other part of the installation.

L.2.8.3 Protection Against Power Surges

Electrical and electronic equipment shall be protected against surges or transients generated by switching operations, electrostatic discharges and induction by lightning and overvoltage arresters.

Compatible overvoltage devices for 'line-side' protection, that includes basic, medium level and detailed protection, shall be installed.

Overvoltage devices shall be installed in accordance with BS EN 60099 and to the manufacturer's recommendations and shall have the following characteristics:

- Modular design
- Visual fault indication
- Remote signalling module
- Replacement of active module (varistor) without interrupting the power supply
- Negligible leakage current
- High discharge capacity
- No follow current when the surge voltage has died down
- Short response time

M. Fire Hydrants

M.1 Post Type Hydrants

M.1.1 Post type fire hydrants shall be dry barrel, manufactured in accordance with AWWA C502 and suitable for a maximum working pressure of 16 Bar. Hydrant sizes shall be 100 mm for 2 outlets and 150 mm for 3 outlets. Stand posts shall be supplied with two 65 mm nozzle hoses for 100 mm hydrants and two nozzle hoses 65 mm and 100 mm pumpers for 150 mm hydrants. Hydrants shall be complete with duckfeet and isolating gate valves. Hydrants shall be of the tilt-off version and shall be provided with intermediate seal bushes to guarantee leak tightness in case of breakage due to traffic accidents.

M.1.2 Post type fire hydrants shall be manufactured from any materials stipulated in AWWA C502 except for materials subject to de-zincification or de-aluminumization.

M.1.3 End connections shall be as shown on the Drawings. Flanged connections, if used, shall be to BS EN 1092-2:1997.

M.1.4 The colour of hydrants and threads of screwed outlet nozzles shall be in accordance with local fire authority requirements.

M.1.5 The direction of rotation of operating nuts to open hydrant shall be counter-clockwise. Operating keys shall be provided at the rate of 1 per 5 hydrants installed or fraction thereof.

M.2 Underground Type Hydrants

M.2. 1 Post type fire hydrants shall the screw-down type manufactured in accordance with BS EN 14339:2005.

M.2. 2 Flange connections shall be in accordance with BS EN 1092-2:1997.

M.2. 3 Threads of screwed outlets or mouthpieces shall suit local fire authority requirements.

M.2. 4 Covers and frames shall cast iron to BS EN 124:1994, medium type.

M.2. 5 Covers shall be opened by keys. The direction of opening shall be counter-clockwise. Operating keys are to be provided at the rate of 1 per 5 hydrants installed or fraction thereof.

N. Service Connections

N.1 Ferrule Cocks

N.1. 1 Ferrule cocks shall be the plug, quarter-turn closing type.

N.1. 2 Ferrule cocks shall be manufactured from cast gunmetal to BS EN 1982:1999 1400 - LG2-C or cast iron to BS EN 1561:1997 grade 12 with a copper alloy plug.

N.1. 3 End connections shall have one end screwed male fitted directly to a pipe saddle and the other end to fit push fit joints to polyethylene pipes or as shown on the Drawings.

N.1. 4 Ferrule cocks shall be suitable for mains network pressure.

N.1. 5 Surface boxes, valve caps, extension spindles and protection tubes and protective covers shall be of the same material as specified for gate valves with dimensions and constructional details as shown on the Drawings and/or to the manufacturer's standards.

N.2 Underground Stop Valves

N.2.1 Underground stop valves shall be manufactured in accordance with BS 5433: 1976 with crutch or square heads.

N.2.2 Unless otherwise shown on the drawings or specified by the Engineer, bodies, leads, glands, spindles and washer plate square heads shall be gunmetal to BS EN 1982:1999, 1400-LG2, seating-washers shall be vulcanized synthetic rubber to BS 3457: 1973 Clause 6 and head sealing '0' rings shall be to BS EN 681-1: 1996 Class D or E.

N.2.3 End Connections: Inlets and outlets of valves shall be internally threaded to BS EN ISO 228-1, Class B, Table 4M to fit threaded specials to polyethylene pipe.

N.3 Taps for Hose Connections

N.3. 1 Taps for hose connections shall be globe valves to BS 5154:1991 suitable for NP16, comprising ductile iron or brass hose outlets to match hose connection tips, enclosed in blockwork boxes for buried installation with ductile iron hinged lockable covers.

N.3. 2 Factory protection of external surface of boxes shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3164:1991 respectively. The minimum coating thickness shall be 250 microns.

N.3. 3 Box locking keys shall be manufactured from ductile iron and supplied at the rate of 1 for every 3 boxes.

N.4 Water Meters

N.4. 1 Water flow meters shall be installed at the locations shown on the Drawings.

N.4. 2 Unless stated otherwise on the Drawings, meters shall be of the helical rotary type to Local Water Authority standards and requirements and approved by the Engineer. Meters shall be accurate to within 5% over the specified flow range.

N.4. 3 The meters shall measure the instantaneous rate of flow as well as total flow.

N.4. 4 No negative reading shall be imposed by the passage of air or suction due to the emptying of the pipe system upstream from the meter.

N.4. 5 Meters shall be made of corrosion and wear-resistant materials and shall have dial glass wipers. Meters shall be protected against unauthorized tampering

O. Valve Accessories and Operators

O.1 Valve Accessories

O.1.1 Handwheels shall be manufactured in accordance with BS 5163:2004, of cast iron to BS EN 1561:1997 Grade 10. Handwheels shall be marked 'CLOSE' with an arrow to indicate a clockwise direction of closure. Diameters and other constructional details shall be to the manufacturer's standards. Handwheels shall be supplied at a rate of 1 in 5 valves.

O.1.2 Valve caps shall be manufactured in accordance with BS 5163:2004, of cast iron or malleable iron to BS EN 1561: 1997. The valve cap set screw shall be mild steel M12.

O.1.3 Operation keys shall be the combination prising bar and lifting key type, with a 1.5 m vertical bar and a 0.5 m horizontal bar. Keys shall be supplied at a rate of 1 for every 5 valves.

O.1.4 Extension spindles for gate valves shall be manufactured from steel in accordance with BS 2470:1973 - M12, galvanized to BS 3382: Parts 1 & 2:1961, size 18 x 18 mm for valves up to 200 mm diameter and 24 x 24 mm for valves 250 mm to 400 mm diameter. The length for each valve size shall suit installation requirements. Spindles shall have cast iron or malleable iron caps and couplings to BS EN 1561:1997 on both sides of extension spindles (the cap for operating spindles and couplings for connecting to valves). Screws of caps and couplings shall be mild steel class M12.

O.1.5 Protection tubes shall be either UPVC or cast iron. The shape, size and other constructional details shall be in accordance with manufacturers' standards and/or as shown on the Drawings. Tubes shall have caps circling extension spindles.

O.1.6 Surface Boxes shall be manufactured in accordance with BS 5834-2:1983. Frames and lids shall be cast iron to BS EN 1561:1997 Grade 10. Studs, bolts, nuts and hinge pins shall be mild steel M12, chains shall be mild steel or wrought iron and lids shall have the letter 'W' cast on. Boxes shall be of the following types:

- For carriageways (wheel loads up to 11.5 tons): heavy grade type A
- For areas of light trafficking: medium grade type M
- In areas inaccessible to motorised vehicles: light grade type L

O.1.7 Lifting key sets shall be malleable iron, supplied at the rate of 1 per 5 covers installed or fraction thereof.

O.1.8 Guards for underground stop valves shall be manufactured from PVC. The shape, size and other constructional details shall be to the manufacturer's standards and/or as shown on the Drawings.

O.2 Valve Operators

Gate, butterfly and ball valves shall be manually or electrically operated depending upon their size, torque applied on the valve stem or as shown on the Drawings:

- Valves 350 mm and smaller shall be operated manually with a maximum applied torque on handwheels of 100 Nm
- Valves 400 - 500 mm shall be operated manually with a maximum applied torque of 150 Nm
- Valves of higher torque shall have appropriate thrust bearings, slides and gearboxes to fulfil these requirements
- Gate valves 600 mm and larger and ball valves shall be electrically operated using thrust bearings, gearboxes and motor actuators
- Butterfly valves 600 mm and larger shall be either manually or electrically operated as shown on the Drawings.

O.3 Manual Gearboxes

O.3. 1 Manual gearboxes shall be totally enclosed and sealed to protect moving parts from damage and corrosion. Gearboxes shall be either the spur or level type depending upon the mounting positions of valves.

O.3. 2 Components include corrosion resistant bearings, cast iron gears, cast housing covers complete with seals and gaskets and handwheel actuators. Housing covers shall have indicator windows to show the position of valves. Gearboxes shall also have stainless steel bolts.

O.4 Electric Valve Operators

O.4. 1 Electric valve operators shall consist of motorized units including gear trains mounted in cast iron housings, flange mounted electric motors, control cabinets and handwheels for manual operation.

O.4. 2 Electric valve operators shall be suitable for flange mounting directly on valve bodies, for gate valves with non-rising stems and for manual operation.

O.4. 3 Electric valve operators shall have adequate horse-power and thrust ratings to open and close operated valves smoothly in all load and pressure conditions.

O.4. 4 Components shall include adjustable mechanical stop-limiting devices to prevent over-travel of the valve in either direction. Operator housings, supports and connections to valves shall have a minimum safety factor of 5 based on the ultimate strengths of the materials used.

O.4. 5 Electric valve operators shall be weatherproof, with rugged cast iron housings and handwheels having appropriate gearing for emergency manual operation with a maximum applied torque of 150 Nm. Declutch levers shall be provided to disengage drive motors during handwheel operations and prevent handwheel rotation during power operation. Handwheels shall close valves in the clockwise direction and have arrows and the word 'CLOSE' cast on.

O.4. 6 Controls shall comprise integral electric controls enclosed within weatherproof compartments, magnetic starters and reversing controllers for motors, open-stop-close push-buttons for local operation, limit switches giving remote indication when the valve is fully opened or closed, torque switches to shut down drives on excessive thrust loads, indicator lights and control voltage transformers.

O.4. 7 Electric motors shall be the totally enclosed, squirrel cage, induction types conforming to NEMA Publication No. MG1 including characteristics, tests and ratings. Motors shall carry the maximum possible loads encountered in valve operation under all normal and abnormal operating conditions without exceeding nameplate ratings and without the inclusion of service factors.

O.5 Valve Chambers and Markers

O.5. 1 Unless shown otherwise on the Drawings all backflow preventers, gate valves, pressure regulators, electric solenoid valves, manual control valves, pressure gauges and water meters shall be installed in precast concrete access boxes of an adequate size for easy access. Access boxes shall be complete with precast concrete covers.

O.5. 2 Unless shown otherwise on the Drawings all access boxes shall be installed on a suitable level base of gravel to provide drainage.

O.5. 3 Valve markers showing the reference numbers of the valves shall be of materials and to the dimensions, shapes and details shown on the Drawings.

P. Jointing Materials

P.1 General

P.1.1 Gaskets shall be elastomeric full face 3 mm thick joint rings to BS EN 681-1:1996 with dimensions to BS 3063:1965.

P.1.2 Rings shall be elastomeric to BS EN 681-1:1996 with dimensions in accordance with the manufacturer's recommendations to suit the type of joint required.

P.1.3 Bolts and nuts shall be isometric black hexagonal to BS 4190:2001 with a minimum tensile strength of 433 MN/m^2 and a maximum elongation of 17%. After fixing, bolt projections shall be maximum of 6 mm, minimum 3 mm.

P.1.4 Washers shall be black steel to BS 4320:1968.

P.1.5 Dielectric joints shall have insulating gaskets between flanges and Teflon sleeves and washers between bolts and nuts and flanges. Joints shall be suitable for the operating pressures of systems.

P.2 Flexible Couplings

P.2.1 Flexible couplings shall be the gasketed sleeve type, allowing angular deflections and axial movements of the two joined pipe ends, maintaining permanent, leak-tight joints.

P.2.2 Flexible coupling components comprise one centre sleeve, two end followers or flanges, two rubber-compounded wedge-section gaskets and sufficient draw bolts and nuts to properly compress the gaskets. Tightening of bolts to draw the end followers together shall compress the gaskets in the recesses between the centre sleeves and followers onto the pipe ends to effect positive seals.

P.2.3 Couplings shall have diameters specifically supplied for and properly fitting the specific types of joined pipe ends. Centre sleeves shall be of adequate thicknesses and whole couplings suitable for minimum working pressures as shown on the Drawings.

P.2.4 Centre sleeve and followers shall be true circular sections, free from irregularities, flat spots or surface defects and formed from steel mill sections with spacees between sleeves and followers designed to provide confinement of gaskets.

P.2.5 Bolts shall be steel having a minimum yield strength of 2800 kg/cm^2 and ultimate strength of 4200 kg/cm^2. Bolts shall track-headed to prevent turning when nuts are tightened and threads shall be rolled with a nominal diameter larger than the shank diameter. The Manufacturer shall supply relevant information regarding recommended torques to which the bolts are to be tightened.

P.2.6 Gaskets shall be made from a synthetic rubber-base compound with other products to produce material which will not deteriorate from age, heat or exposure to air and which is resilient and able to resist cold flow of material so that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation, temperature and adjustment of connected pipes.

P.2.7 Couplings shall be factory painted internally with a 5 mm coating of epoxy and externally with red primer to AWWA 203 Type B chlorinated rubber solution compatible with bitumen, coal tar and general paints.

P.2.8 Couplings shall be assembled on site in accordance with the manufacturer's instructions to ensure permanently tight joints under all conditions of expansion, contraction, shifting and settlement.

P.3 Demountable Couplings

P.3.1 Demountable couplings shall be mounted next to valves to enable easy dismantling from pipework or to permit joining pipework when butterfly valves are removed for maintenance.

P.3.2 The demountable section shall be a flanged type composed of two parts with one part sliding into the other and a free flange to compress a trapezoidal section seal to ensure watertightness. Couplings shall have locking devices as approved by the Engineer..

P.3.3 Flanges shall be constructed of steel class PN 10, PN 16 or PN 25 depending upon the coupling location on pipework and to the Engineer's approval.

P.3.4 Couplings shall have diameters specifically supplied for and properly fitting the types of joined ends of pipes and valves. Couplings shall permit tightening of end flanges without risk of misalignment. Seals shall be locked after end joints are tightened.

Q. Irrigation Valve Accessories and Operators

Q.1 Valve Boxes

Valve boxes shall be manufactured from glass reinforced plastic (GRP) or plastic conforming to the following specifications.

Q.1.1 GRP Valve Boxes

A. GRP Valve Boxes shall be designed to suit site conditions and loadings. GRP shall be manufactured from E-glass type fibres and thermosetting resin and shall incorporate a corrosion resistant liner. Glass fibres shall be compatible with the resins used. Liners shall comprise inner faces of a smooth hard suitably reinforced resin rich layer. Exterior surfaces of valve boxes shall be be resin rich.

B. Inside surfaces of the valve boxes shall be hard, durable, free of tackiness, bulges, dents, ridges or other defects that result in a variation of the inside dimensions of more than 3 mm.

C. No glass fibre reinforcement shall penetrate the interior surfaces of valve box walls, and any glass fibre reinforcement on the exterior surface shall be thoroughly impregnated with resin.

D. The glass content shall be determined by ignition loss analysis in accordance with ASTM Method D 2584 or BS EN ISO 1172:1999.

Q.1.2 Plastic Valve Boxes

Plastic valve boxes shall be manufactured from a high impact, acid and heat resistant, self extinguishing, hard, durable, low coefficient of expansion PVC compound.

Q.2 Programme Controllers

Q.2.1 Programme controllers shall be hybrid types (combining electro-mechanical and micro-electronic circuiting), with four independent programmes capable of fully automatic or manual operation of the remote solenoid valves, 14-day calendar dials for every day or every other day or any sequence starts, time-setting control up to 60 minutes per station in 2 minutes increments 23 starts per day. The number of stations shall be as indicated on the Drawings or in the Bill of Quantities. The maximum number of 24 V AC solenoid valves that can be controlled by a station is 4. The controller shall allow for valve power output to be interrupted without affecting the controller timers.

Q.2.2 The controller shall have a start circuit to activate a remote pump start relay to run the pump during the irrigation cycle.

Q.2.3 The controller shall allow for opening the first remote control valve before operating the pump and also for closing the last remote control valve within 15 seconds after stopping the pump.

Q.2.4 The controller shall be installed in a pedestal mounted, weatherproof, heavy-duty, locking steel cabinet. The pedestal shall include terminal strips for quick connection of cables.

Q.2.5 Controllers shall accept a 220 V 50/60 cycle current; with 24 VAC solenoid valves; output power surge protection; a master on-off switch and one arrestor for each valve wire and for the common or earth wire.

Q.2.6 Controllers shall be from the same manufacturer as the remote control valves.

Q.3 Cabling for Irrigation Control

Q.3.1 Low voltage wiring from automatic controllers to remote control valves shall be directly buried, 600 volt solid copper single conductor wire with heat resistant insulation of a minimum 0.4 mm thickness. The Contractor shall submit proposed low voltage wire routing shop drawings for the Engineer's approval prior to installation. The low voltage wire shall be encased in 5 mm diameter conduits.

Q.3.2 Medium voltage cables shall conform to the requirements of BS 5467:1997 or IEC 60502. Cables shall be 600/1000 volt grade, multicore stranded copper conductors, cross-linked polyethylene (XLPE) insulated and UPVC oversheathed type. The service cable for irrigation controllers shall be 3 core 10 mm^2 minimum.

Q.3.3 Conductors shall be annealed stranded copper in accordance with BS 6360:1991. Conductor insulation shall be moisture and heat resistant to 90^{o}C, conforming to BS EN 60811. The cable cores, unless otherwise approved by the Engineer, shall be coloured as follows:

- Single phase system: red (phase), black (neutral), green or green/ yellow (ground).

8.03.3 WORKMANSHIP

A. General

A.1 Prior to installation, the Contractor shall inspect for cleanliness of bores, seating surfaces and handling damage, cracks, missing parts and tightness of pressure-containing bolting.

A.2 Gates and hydrants shall be set to the closed position before installation.

A.3 Valves and hydrants shall be operated through one complete opening and closing cycle at the settings at which they are to be installed to ensure correct functioning.

B. Installation

B.1 Valves

B.1.1 Valves shall be set and jointed to pipes in accordance with the specifications, standards and manufacturer's instructions.

B.1.2 Valves shall be provided with class 210/25 concrete pads as shown on the Drawings so that the adjacent pipes do not support their weight.

B.1.3 Valves without concrete pads shall be placed on firm footings to prevent settling and excessive strain on connections to pipes.

B.1.4 Valves shall not be used to bring misaligned pipes into alignment during installation.

B.1.5 The Contractor shall inspect all pressure-containing bolting (bonnets, seal plates and end connections) for adequate tightness after installation but prior to field testing.

B.2 Sluice Gates

B.2.1 The Contractor shall install gates, walls thimbles, operating mechanisms, stems and stem guides in accordance with the manufacturer's drawings and recommendations. Care shall be taken to avoid warping the frame and to maintain the tolerance between seating faces.

B.2.2 The Contractor shall protect tapped holes in thimbles during concreting and setting.

B.2.3 The Contractor shall protect the surfaces of thimbles and gates from concrete spillage, paint, oil and debris.

B.2.4 The Contractor shall support thimbles to prevent shifting during pouring and provide horizontal and vertical bracing to prevent distortion.

B.2.5 The Contractor shall tighten nuts in sequence after setting.

B.2.6 The Contractor shall adjust and lubricate the entire assembly after installation.

B.2.7 The Contractor shall operate the completed sluice gates through one complete cycle to ensure proper functioning.

B.3 Penstocks

B.3.1 General

B.3.1.1 Penstocks shall be water-tight under the conditions of head and direction of flow as stated in the Drawings or as specified by the Engineer.

B.3.1.2 All bolt holes shall be drilled and spot faced.

B.3.1.3 Simple templates shall be supplied for all penstocks over 1 m^2 as soon as possible after approval of drawings in order to position the holes for holding down bolts.

B.3.2 Installation

B.3.2.1 Each tube shall be clearly and permanently engraved to indicate the position of the penstock.

B.3.2.2 For each penstock, the wall thimble, operating mechanism, stem and stem guides shall be installed in accordance with the manufacturer's recommendations. Tolerances between seating faces shall be maintained and any warping avoided.

B.3.2.3 Tapped holes in thimbles shall be protected during concreting and setting. Surfaces of thimbles and gates shall be protected from concrete spillage, paint, oil and debris. Thimbles shall be supported to prevent movement during pouring and braced horizontally and vertically to prevent distortion.

B.3.2.4 Nuts shall be tightened in sequence after setting and the entire assembly shall be cleaned, adjusted and lubricated after installation.

B.3.2.5 Penstocks shall be operated through one complete cycle on installation to ensure proper functioning.

B.3.2.6 Penstocks shall be protected against the action of external agents with one coat of approved bituminous compound applied cold by brush after installation. Buried bolts, etc. shall be protected against corrosion with approved paint or polyethylene wrapping.

B.4 Hydrants

B.4.1 Hydrants shall be joined to pipes in accordance with the specifications, standards and manufacturer's instructions.

B.4.2 Hydrants shall be set to established grades as directed by the Engineer.

B.4.3 Hydrants shall be set plumb with nozzles and parallel with or at right angles to the curb. Where hydrants have single pumper nozzles, these shall be set facing the curb. Where hydrants have two hose nozzles 90^{o} apart, these shall be set with each nozzle facing the curb at a 45^{o} angle.

B.5 Field Protection

B.5.1 Valves shall be protected by a coat of bituminous compound, as approved by the Engineer, applied cold by brush after pressure testing on pipelines has been completed.

B.5.2 One coat of paint shall be applied to hydrants, of a colour specified by the Engineer, after backfilling and surface restoration has been completed.

B.5.3 Gates shall be protected with one coat of bituminous compound, as approved by the Engineer, applied cold by brush after installation.

B.5.4 Buried bolts shall be protected against corrosion with a paint approved by the Engineer or by polyethylene wrapping.

F. Installation of Irrigation System Components

F.1 Installation of Valves

F.1.1 Prior to installation, valves shall be inspected for cleanliness of bore, seating surfaces etc. and for handling damage, cracks, missing parts and tightness of bolting. Valves shall be in the closed position before installation.

F.1.2 Valves shall be operated through one complete opening and closing cycle in the position in which they shall be installed to ensure proper functioning.

F.1.3 Valves shall be set and jointed to the pipe as specified for laying and jointing pipes and in accordance with the manufacturer's recommendations. Each valve shall be provided with a concrete pad as shown on the Drawings so that the pipe does not support the weight of the valve. Valves shall not be used to spring a misaligned pipe into alignment during installation.

F.1.4 All stressed bolts (bonnets, seal plates and end connections) shall be inspected for adequate tightness after installation and prior to field-testing.

F.1.5 Valves shall be protected against the action of external agents by a coat of approved bituminous compound, applied cold by hand brushing after pressure tests on pipelines have been completed. Buried bolts shall be protected against corrosion, with approved paint or polyethylene wrapping.

F.2 Installation of Other Irrigation System Components

F.2. 1 Irrigation components forming a control head shall be located in downstream order as follows: backflow preventer, control valve, fertilizer applicator and gate valve, pressure gauge, filter, pressure gauge, electric solenoid valve, water flow meter and pressure regulator.

F.2. 2 Filter and fertilizer applicator equipment shall be mounted on a concrete pad forming an integral installation. The filter shall be located downstream of the fertilizer applicator to prevent contamination from the injection process. The concrete pad shall be Class 210/20 with dimensions as recommended by the equipment manufacturer.

F.2. 3 The installation of miscellaneous components of the system shall be in accordance with the manufacturer's instructions.

8.03.4 MEASUREMENT

A. Valves and Accessories

A.1 Valves and taps shall be paid for per unit installed according to the size and type indicated in the Bill of Quantities.

A.2 Rates for gate and butterfly valves shall include for:

1) Supply of valves as specified,
2) Lowering into the trench and installing,
3) Over-excavation for concrete supports and boxes,
4) Concrete supports and thrust blocks. Concrete work shall include all items required for Concrete Work and Concrete Structures,
5) Appropriate fittings and/or couplings and dismantling joint for connecting to adjacent pipe or fitting,
6) Flanged and socket adaptors necessary for connecting to adjacent spigot ends,
7) Valve chambers complete with cover lock and rungs as shown on Drawings for valves placed in chambers,
8) Valve surface box complete with cover, lock and key and concrete surround for directly buried valves,
9) Bolts, nuts, gaskets, operating keys, hand wheels and others,
10) Ancillary works and material required,
11) Painting, lining and coating,
12) Extension spindles plus square nuts to fit spindles.

A.3 Rates for air valves shall include for:

1) Supply of valves as specified,
2) Tees and/or saddles for connecting to the main line,
3) Isolating gate valves,
4) Drilling and fixing the flanged spool outlets for air valve connections,
5) Ancillary works and materials required,
6) Installing, painting, coating and testing,
7) Concrete valve chamber complete with cover and lock as shown on the Drawings.

A.4 Rates for drain and flush valves include for:

1) Supply of material, items forming the complete unit, as shown on the Drawings, including pipes, flexible couplings, valves, flanged pipes, duckfoot elbows, housing and polyethylene pipes
2) Bolts, nuts and gaskets.
3) Thrust and support blocks.
4) Valve chambers complete with covers, locks, surface boxes and rungs.
5) Factory painting, lining and coating.
6) Ancillary works and materials.
7) Polyethylene pipe diameter 150 or 200 mm, 50 m long with protection and anchorage at outlet to allow free discharge to the drainage outfall.
8) Ductile iron pipe and flexible couplings between invert level tees and valve chambers.
9) Installing, painting, coating and testing.

A.5 Rates for taps for hose connections shall be paid per connection installed.

A6 Rates for taps for hose connections shall include:

1) Supply of all materials including pipes, fitting specials and service boxes and covers.
2) Supply of stopcocks and saddles on mainline. Excavation bedding and backfilling, concrete works and reinstatement.
3) Installation and connection to new network and to the service box, or to the existing service connection and testing.

B. Sluice Gates and Penstocks

Sluice gates and penstocks shall be measured and paid for per unit installed according to size and type indicated in the Bill of Quantities.

Rates for sluice gates and penstocks shall include for:

1) Gates.
2) Frames, rubber bottom seals, anchor bolts, stem and stem guides.
3) Lifts with wall brackets, anchor bolts and handwheels.
4) Cleaning and painting.
5) Assembly, installation, testing and adjustment.
6) Stop planks.

C. Fire Hydrants

C.1 Fire hydrants shall be paid for per unit installed according to the type indicated in the Bill of Quantities.

C.2 Rates for fire hydrants shall include for:

1) Supply of material, items forming the complete unit including pipes, flexible couplings, valves, flanged pipes, duckfoot elbows, housing and polyethylene pipes
2) Bolts, nuts and gaskets.
3) Thrust and support blocks.
4) Valve chambers complete with covers, locks, surface boxes and rungs.
5) Factory painting, lining and coating.
6) Ancillary works and materials.
7) Installing, painting, coating and testing.

D. Irrigation System Components

D.1 Rates for irrigators (irrigation equipment and accessories excluding drip emitter distribution tubing) shall be measured by the number of each type and size installed, completed and accepted be paid per unit installed

D.2 Drip emitter distribution tubing shall be measured by the linear metre of each size installed, completed and accepted.

D.3 Spares for the irrigation system shall be a Prime Cost Item and shall be measured by the number of each type and class of spare part authorized by the Engineer, purchased by the Contractor, handed over and accepted.

D.4 Rates for irrigators shall include for:

1) Supply of material, items forming the complete unit as shown on the Drawings,
2) Bolts, nuts, gaskets and operating keys,
3) Excavation and backfilling,
4) Supply of equipment and appropriate fittings and or couplings for connection to adjacent networks
5) Valve boxes complete with locking covers and marker posts
6) Lowering into the trench and installing,
7) Installing, painting, coating, lining and testing

PAY ITEMS		**UNIT OF MEASUREMENT**
(8.3.1)	Valves *(state type & size)*	Number (No)
(8.3.2)	Taps for Hose Connection *(state type & size)*	Number (No)
(8.3.3)	Sluice Gates *(state type & size)*	Number (No)
(8.3.4)	Penstocks *(state type & size)*	Number (No)
(8.3.5)	Fire Hydrants *(state type & size)*	Number (No)
(8.3.6)	Irrigation Program Controllers *(state type & size)*	Number (No)
(8.3.7)	Irrigators *(state type & size)*	Number (No)
(8.3.8)	Drip Emitter *(state type & size)*	Linear metre (m)
(8.3.9)	Spares for Irrigation System	Item

SECTION 8.04 SURROUND, HAUNCHING, ENCASEMENT & THRUST BLOCKS

8.04.1 SCOPE

The work covered in this section includes in-situ concrete work and other fills necessary for the installation of drainage pipe installation.

Concrete work shall comply with the appropriate requirements of Section 5: Concrete, Steel and Structures.

8.04.2 MATERIALS

A. Compressible board shall be 20 mm thick compressible fibrous board or similar material approved by the Engineer.

B. Fill Material Under and Around Pipes

B.1 Material under and around pipe (pipe surround and backfill) shall comply with the appropriate requirements of Specification Section 2: Earthworks.

B.2 Concrete bedding shall be in situ concrete Class 110/25.

B.3 Concrete encasement, thrust blocks, arches and haunches shall comprise in-situ concrete Class 250/20.

8.04.3 WORKMANSHIP

A. Placing Concrete

A.1 After the laying of pipes in the trench, concrete shall be placed and compacted under the pipes to provide a solid and uniform surround.

A.2 After pipe jointing has been completed the outstanding concrete or haunching shall be placed and compacted on both sides simultaneously.

A.3 Vertical construction joints shall be formed in the concrete at the faces of pipe joints using compressible board and finished to the profile of the concrete and pipes. Gaps between spigots and sockets shall be filled with resilient material approved by the Engineer.

B. Placing Material Other Than Concrete

B.1 Surround material shall be placed in the bottom of prepared trenches and hand tamped to the minimum thicknesses specified on the Drawings or instructed by the Engineer.

B.2 When the pipe has been laid, additional material or haunching shall be placed in successive layers not exceeding 150 mm thick simultaneously on both sides. All spaces between pipes and the sides of trenches shall be filled and carefully hand tamped without disturbing the pipes.

C. Thrust Blocks

Thrust blocks shall be provided at bends and other fittings on pressure pipelines. The additional excavation required shall be undertaken after the pipeline has been jointed. No pressure shall be applied to the thrust block until the concrete has matured for at least 3 days.

8.04.4 MEASUREMENT

Concrete encasement for pipelines shall be measured by the cubic metre of concrete calculated on the basis of dimensions indicated on the Drawings after deducting the pipe section.

All other material and work items mentioned above, including compressible boards, surround, backfill and haunching material and thrust blocks shall not paid for separately but shall be included in their respective pay items as indicated elsewhere in the specification.

PAY ITEM		UNIT OF MEASUREMENT
(8.04.1)	Concrete Encasement for Pipes	Cubic Metre (m^3)

SECTION 8.05 MANHOLES, CHAMBERS AND GULLIES

8.05.1 SCOPE

The work covered in this Section includes the furnishing of all materials, construction, installation, connection and completion of manholes, catch pits, valve chambers, kerb inlets, interceptors, access shafts, inspection chambers and gullies for drainage, sewer and water supply systems.

8.05.2 GENERAL

A. Excavation and backfilling shall comply with the appropriate requirements of Section 2: Earthworks.

B. Concrete work shall comply with the appropriate requirements of Section 5 Concrete, Steel and Structures.

C. The method of reinforcing shall conform to the requirements of Section 5.03: Steel Reinforcement.

8.05.3 MATERIALS

A. Concrete shall conform to the requirements as specified in Section 5.01: Concrete Mixes and Testing.

B. Reinforcement shall conform to the requirements as specified in Section 5.03 Steel Reinforcement.

C. Structural steel shall conform to the requirements as specified in Section 5.16 Structural Steelwork and Metal Components.

D. Pipes shall conform to the requirements of Section 8.02: Pipes and Appurtenances or Section 5.13: Concrete Pipe Culverts as appropriate

E. Precast concrete manhole sections shall be manufactured in accordance with BS EN 1917:2002 using reinforced concrete Class 250/20. Cement shall be ordinary Portland cement. to BS EN 197-1: 2000.

F. Cast in situ units shall be constructed in plain and reinforced concrete class 210/25 and 250/20 respectively. Cement shall be ordinary Portland cement to BS EN 197-1: 2000.

G. Bricks shall be manufactured in accordance with BS 3921:1985 and BS EN 772:1998.

H. Precast concrete blocks for masonry walls shall conform to BS EN 771-3: 2003 and BS EN 772-2:1998.

I. Vitrified clay pipes and tiles shall conform to the requirements as specified in

- AASHTO M65: Vitrified clay pipes, extra strength, standard strength and perforated clay drain tiles
- AASHTO M179: Clay drain tiles

J. Corrugated aluminium alloy culverts and underdraws shall conform to the requirements as specified in AASHTO M196: Corrugated Aluminium Alloy Culverts and Underdrains

K. Grey cast iron castings shall conform to AASI-ITO M105 (ASTM A48) Class 25 or higher. Castings shall be manufactured to the sizes and dimensions shown on the Drawings.

L. Test bars shall be prepared and tested as specified in AASHTO M105.

M. Steel castings: mild to medium strength castings shall conform to AASHTO M103 (ASTM A27). Unless otherwise shown on the Drawings or instructed by the Engineer, castings shall be grade 65-35 fully annealed. Steel castings shall conform to the dimensions shown on the Drawings. Test bars shall be prepared and tested as specified in AASHTO M 103.

N. Wrought iron plates and shapes shall conform to the dimensions shown on the Drawings. Rolled wrought iron bars and shapes shall conform to the requirements of ASTM A207. Wrought iron plates shall conform to ASTM A42.

O. Covers and frames shall be manufactured from ductile iron in accordance with BS EN 124:1994, non-rock, locking and solid tops. The wording on covers shall indicate the nature of the network (water supply, sewage, stormwater, etc). Grades of covers shall be as follows:

- For roadways: Grade A, heavy duty test load 40 tons
- For sidewalks, carriage drives and cycle tracks: Grade B medium duty test load 25 tons
- For footpaths and fields: Grade C light duty, test load 7 tons

P. Manhole covers shall be of a circular pattern unless otherwise indicated on the Drawings. Frames shall be provided with openings for fixing bolts for solid frame embedment into manhole concrete necks. Covers and frames shall be coated with a bitumen based compound to BS 3416:1991 with a minimum thickness of 200 microns.

Q. Road Gully Gratings shall be manufactured in accordance with BS EN 124:1994, non-rock and coated in accordance with BS 3416:1991 with a minimum thickness of 200 microns. Types of gratings to be used shall be as follows:

- Carriageways: Grade A, minimum test load 40 tons.
- Footpaths, cycle tracks and fields, light duty, test load 7 tons.

R. Step Irons shall be manufactured in accordance with BS EN 13101: 2002.

S. Steel Ladders shall be manufactured in accordance with BS 4211:2005, mild steel, galvanized to BS EN ISO 1461:1999 with 200 grams of zinc per square metre.

T. Safety Chains shall be 12 mm diameter wrought iron short link chains, galvanized in accordance with BS EN ISO 1461 with 200 grams of zinc per square metre.

U. Guardrails shall be either of the following:

- Tubular mild steel, medium grade to BS EN 10255:2004 with screwed joints, galvanized to BS EN ISO 1461:1999 with 200 grams of zinc per square metre.
- Round steel solid bars to BS 6722:1986 with welded joints galvanised in accordance with BS EN ISO 1461:1999 with 200 grams of zinc per square metre.

V. Fixing bolts shall be manufactured from steel and of a type suitable for the particular purpose and to the approval of the Engineer. When used to fix galvanized material, washers shall be galvanized and fixing bolts and nuts cut to pre-plating limits and electroplated with zinc to BS EN ISO 1461:1999.

W. Coatings

Internal surfaces of precast concrete manholes and chambers shall be treated with a coal tar or bitumen epoxy coating if so detailed on the Drawings.

External surfaces of precast concrete manholes and chambers shall be protected with waterproofing bitumen supplied and applied in accordance with the requirements of Section 5.15 of Section 5: Concrete, Steel and Structures.

8.05.4 CONSTRUCTION

A. Manholes and Inspection Chambers

A.1 Manholes and inspection chambers shall be constructed from in-situ concrete or precast concrete as shown on the Drawings or as proposed by the Contractor and approved by the Engineer. In-situ units shall be constructed in accordance with Specification Section 5: Concrete Works.

A.2 Precast units shall be cast in steel watertight forms for at least 3 weeks before the sections are used. Precast units shall be assembled on an in-situ concrete base and bedded on and sealed with cement mortar. Prior to fixing, joints of precast units shall be either completely coated with bituminous material or sealed with a preformed jointing strip, all in accordance with manufacturer's instructions or as detailed on the Drawings and approved by the Engineer. Any surplus jointing material extruded inside the chamber or shaft shall be trimmed off and joints shall be pointed on completion. This work shall be left undisturbed for 7 days. Precast concrete cover slabs shall be bedded on cement mortar.

A.3 Channels in bottoms of manholes shall be smooth, semi-circular with a diameter equal to the adjacent sewer pipes. For straight- through manholes, channels shall be constructed from half pipe sections. Changes in direction of flow shall be accommodated with smooth curves as large as the manholes permit. Changes in the size and grade of channels shall be gradual and even.

A.4 Benching shall be formed in concrete Class 110/25 rising vertically from the top of the channels to the level of the soffit of the outlet pipe and thereafter sloping upwards at 1 in 10 to the walls. Within 3 hours of completion of benching, a coat of sulphate resisting cement-sand mortar 1:2 shall be applied and smoothed using a steel trowel.

A.5 External faces of manholes and chambers shall be protected by three layers of brush-applied bituminous paint with a minimum thickness of 600 microns and in accordance with Section 5: Concrete Steel and Structures or as detailed on the Drawings or as specified by the Engineer.

A.6 Internal faces of manholes and chambers shall be covered with four coats of coal tar epoxy paint, 70% epoxy and 30% coal tar as detailed on the Drawings or as approved by the Engineer, applied by brush in accordance with the manufacturer's instructions. The minimum thickness of coating shall be 1000 microns.

A.7 Step irons shall be cast into precast units or grouted into preformed mortises. Step irons shall not be used as lifting eyes. Devices for lifting and handling precast units shall be provided on exterior faces only.

A.8 Top courses of brickwork or concrete rings shall be completed only after completion of the surrounding roadworks to ensure that the cover is flush to the finished surface.

A.9 Covers and gratings shall be embedded in mortar and seated firmly using fixing bolts. Covers shall be positioned centrally over openings and be level and square with surrounding the finish.

A.10 Manholes shall be tested on completion by plugging inlets and outlets, filling with water and standing for at least 24 hours or such longer period to allow for complete absorption. The manhole shall then be refilled with water. The allowable leakage after refilling over 24 hours shall not exceed 1% of total volume of the manhole. If a manhole fails this test it shall be made good and retested.

B. Valve Chambers

B.1 Valve chambers shall be constructed using in-situ or precast concrete or blockwork as shown on the Drawings.

B.2 External faces of valve chambers shall be protected by two layers of brush-applied bituminous paint with a minimum thickness of 400 microns and in accordance with Section 5: Concrete Steel and Structures or as detailed on the Drawings or as specified by the Engineer.

B.3 Covers shall be embedded in mortar and seated firmly using fixing bolts. Covers shall be positioned centrally over openings and be level and square with surrounding finishes.

C. Road Gullies and Kerb Inlets

Road gullies and kerb inlets shall be constructed using in-situ or precast concrete to the size and shape indicated on the Drawings and conforming to the construction requirements for manholes.

8.05.5 MEASUREMENT

A. Manholes, drop inlets, catch basins, catchpits, kerb inlets, ditch inlets and ditch outlets shall be measured by the number of each type constructed, completed as shown on Drawings and accepted including protective painting, furnishing and installation of all materials, frames, grates, covers and steps.

B. Channel grating basins shall be measured by the linear meter of each clear opening width, constructed, completed and accepted including furnishing and installation of all materials, frames and grates.

C. No separate measurement or payment shall be made for any excavation, shoring, sheeting or backfilling or for breaking into existing pipes, channels or culverts in order to install new manholes, catch basins, catchpits, drop inlets, kerb inlets, ditch inlets, ditch outlets and channel grating basins; all such work being considered subsidiary to the relevant pay items.

D. No separate payment shall be made for blinding, protective and bituminous painting, equipment, forms, tools, furnishing and placing materials, labour or any other item necessary for the proper completion of the work.

PAY ITEMS	**UNIT OF MEASUREMENT**
(8.05.1) Manholes (*Specify type, size and depth*)	Number (No)
(8.05.2) Road Gully (*Specify type, size and depth*)	Number (No)
(8.05.3) Interceptors (*Specify type, size and depth*)	Linear Meter (m)
(8.05.4) Kerb Inlet (*Specify type, size and depth*)	Number (No)
(8.05.5) Catch Basin (*Specify type, size and depth*)	Number (No)
(8.05.6) Inspection Chamber (*Specify type, size and depth*)	Number (No)
(8.05.7) Access Shaft (*Specify type, size and depth*)	Number (No)
(8.05.8) Valve Chamber (*Specify type, size and depth*)	Number (No)
(8.05.9) Catchpit (*Specify type, size and depth*)	Number (No)
(8.05.10) Ditch Inlet (*Specify type, size and depth*)	Number (No)
(8.05.11) Ditch Outlet (*Specify type, size and depth*)	Number (No)
(8.05.12) Channel Grating (*Specify type and size*)	Linear metre (m)
(8.05.13) Drop Inlet (*Specify type, size and depth*)	Number (No)