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27. TUBE-WELL AND WATER SUPPLY

27.1 CONSTRUCTION OF TUBE-WELLS

27.1.1 SCOPE

The work covered shall consist of well drilling, installation of components, shrouding, development and testing including all plant, labour, equipment &other miscellaneous works necessary for the satisfactory completion of the tube-well as specified and approved by the Engineer-in-Charge.

Before proceeding with the work the Contractor shall submit a complete work plan for performing the work. This will include but be not limited to manpower, Plant and equipment and schedule of performance for completion of work.

The Contractor shall employ at site a fulltime competent Superintendent for overall supervision of the work.

27.1.2 DRILLING

27.1.2.1 GENERAL

The Contractor shall drill bore hole for the tube-well at the designated location established by the Engineer-in-Charge, The Contractor shall prepare the site for the construction of the tube-well and shall provide for water for construction requirements, the disposal of water, cuttings and refuse from the operations away from the tube-well.

27.1.2.2 DRILL CONDITIONS

General overall conditions related to the ground water at the site of tube-well if available will be made known to the Contractor. The contractor is expected to make his own assessment of the character, quality and the conditions that may be encountered and shall take full responsibility for performance of work as specified.

27.1.2.3 DRILLING PROCEDURE

The bore hole shall be drilled either by director reverse circulation rotary method, The diameter of the drilling bit shall depend on the bore size as specified on drawings oras directed by the Engineer-in-Charge. The bore hole shall be drilled straight and plumb so that the pump and tube-well casing may, be installed concentric with the hole and within the tolerance specified for plumpness of the casing. Waste materials from the drilling operation shall be disposed of in a manner approved by the Engineer-in-Charge.

The Contractor shall be responsible for protecting the tube-wells from contamination with foreign materials until the completion of the tube-well. The Contractor shall bear any expense that may result from any damage to tube-well, tools, or equipment that may be caused by caving, washing, or other disturbances within the tube-wells.

To prevent sloughing and caving of surface material and/or the hole, the Contractor shall furnish and install a boring casing pipe with a minimum diameter 2 inches greater than the bit diameter from not less than 6 inches above the ground surface to bottom of the hole. The casing pipe shall be new or used pipe of adequate strength for the purpose. After the drilling is completed, the casing pipe shall be removed by the Contractor and shall remain his property.

The use of drilling fluid additives or other suitable materials specially approved by the Engineer-in-Charge may be applied in stabilizing the bore hole. The casing shall be removed by the Contractor after the installation of pump housing pipe along with the strainer in the bore hole. However in case of the tube-wells where shrouding material is to be provided around the periphery of the strainer (or

around the strainer and the pump housing pipe) and the inner walls of the bore hole the casing shall be removed in 1.5 to 3 meters stages as shrouding is placed.

If in the opinion of the Engineer-in-Charge, it is necessary to discontinue work on any bore hole because it is out of line more than the specified limit or on account of jammed tools, or caving ground, or because of negligence on the part of the Contractor, the Contractor shall drill another bore hole at an alternative location designated' by the Engineer-in-Charge. The Contractor will not be entitled to payment for any work done or materials furnished for bore holes abandoned as a result of his operation or negligence.

27.1.2.4 DATA AND RECORDS

The Contractor shall keep an accurate drilling log of each bore hole including a description of all materials encountered and their location in the bore hole.

All records and data shall be kept by the Contractor on forms approved by the Engineer-in-Charge. The Contractor shall deliver to the Engineer-in-Charge the original of all records completed in all respects.

27.1.2.5 SAMPLING

Representative ditch samples or cuttings of the material penetrated shall be taken at every 5 ft. (1.5 m) depth of borehole or at each change in litho-logy encountered whichever is less. Special care shall be exercised to determine the thickness and location of each change in material encountered and to obtain satisfactory samples. Immediately upon taking the sample, each sample shall be placed in a plastic or cloth bag or specified partitioned wooden box, or other approved container, properly marked for identification, and plainly labelled with the depth of the top and bottom of the section of the bore hole represented. The containers shall be furnished by the Contractor. The method of obtaining, processing, and storing the samples will be subject to approval by the Engineer-in-Charge. The Contractor shall deliver all samples to the Engineer-in-Charge at the site of the tube-wells, except that when requested to do so by the Engineer-in-Charge, the Contractor shall deliver specified samples to the Engineer's field headquarters.

27.1.3 INSTALLATION OF TUBE-WELL COMPONENTS

27.1.3.1 GENERAL

Installation shall consist of all work required in connection with the erection of pumping housing pipe, blind pipe, reducer, screen and bail plug/ sand trap required. for each tube-well as specified herein or on the Drawings or as directed by the Engineer-in-Charge and shall include, but not be limited to storing, fabricating and installing all the tube-well components including concentric reducers.

27.1.3.2 MATERIALS

i) Pump Housing Pipe

The housing pipe made of mild steel or PVC may have the same diameter as that of the other components or it may be bigger in which case tapered joint/reducer shall be used for connection of the housing pipe with the lower part of tube-well.

The mild steel pump housing pipes shall be new and shall be either seamless (Type S Grade 8 ASTM A-53), longitudinal welded (Type E Grade 8 ASTM A-53) or special seam fusion welded (Grade 8 ASTM A-139) mild steel of designated diameters and thickness indicated in the drawings.

PVC housing pipe shall conform to BSS-3505/1968.

All these pipes shall be free from dents, injuries, scars and oval ties. The pump housing pipe shall be installed to extend above ground level as approved by the Engineer-in-Charge in addition to the housing as specified below ground level.

ii) Well Blind Pipes

Well blind pipes shall be of designated diameters as indicated in the drawings, which shall be fabricated in conformity with the specifications designated here above for pump housing pipes.

Fibre glass well blind pipes whenever used shall be new and shall consist of glass reinforced plastic pipe and couplings manufactured from thermosetting epoxy resins and glass fibre by either centrifugal casting process or by a filament winding process, both using continuous filaments and without the addition of fillers or pigments of any kind.

Glass fibre used in the manufacture of pipe and couplings shall be continuous filament, electrical glass.The glass shall have a finish suitable for use and compatible hardener. Each glass fibre or filament shall be thoroughly coated with epoxy resin.

All fibreglass casing pipe and couplings shall be round and straight of uniform quality and workmanship, and free from all defects including indentations, delaminations, bends, cracks, blisters, porosity, dry spots, resin segregation and resin starved areas which due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe and couplings. The impregnation of the glass fibres with resin shall be such that when the pipe is slotted no fraying or looseness of glass fibres shall be evident. All pipe ends shall be cut at right angles to the axis of the pipe and any sharp edges shall be removed. The inside of the pipe and couplings shall be smooth and uniform. Acetone rub tests may be employed to check resin nature and curing.

Pipe sections may be furnished with integrally fabricated couplings as specified herein- after, with plain or tapered ends for connection in the manufacturer's plant to separate coupling halves or with threaded ends for connection by means of threaded couplings. The Contractor shall be responsible for the co-ordination of all casing components to ensure proper connection to adjoining sections of the tube-well casing and the M.S Pump housing casing.

Couplings for fibreglass casing pipe may be threaded, mechanical or Key type couplings of a design to be approved by the Engineer-in-Charge. The couplings shall be manufactured of the same materials used in the manufacture of the fibreglass pipe separate components for attachment to the pipe section in the manufacturer plant.

All threaded pipe sections shall be field connected by the use of threaded fibreglass couplings. Thread geometry shall conform with the applicable sections of ASTM Standard: D -1694 or equivalent.

Key-type couplings shall consist of male and female halves designed for joining & locking together by means of key strip inserted in grooves in the coupling halves. The wall thickness at the groove on the male or spigot end of the pipe may be upto a minimum of 0.15 inches. Key strip and locking strips shall be fibreglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the minimum axial tensile load for the couplings.

iii) Reducer

In case where the size of the pump housing pipe is larger than the size of the strainer, the Mild steel pump housing pipe is connected with strainer or blind pipe by means of a reducer. The reducer shall be provided and made of the same material and of the same thickness as used for pump housing pipe specified above. The upper end of the reducer shall be suitable for welding to the pump housing pipe and the lower end shall be designed for connection to the specified size and type of the well blind pipe.

iv) Bail Plug/Sand Trap

Bail plug/Sand trap shall be of the same material and thickness as followed for well casing. Sand trap shall be provided with a base plate, welded at one end of the pipe. A steel hook bent in the form of 'U' shall be bolted to the base plate to sustain suspended length casing including the

strainer and blind pipe. Bail plug/Sand trap shall be one to three meters long in size or as indicated in the drawing.

v) Well Screen

Well screen shall be either brass, PVC or fibreglass suitable for gravel pack tube-well and strong enough for location at a depth as shown' on the drawings, below ground level.

The strainer shall have smooth, sharp edged slots free of burrs, chipped edges, or broken areas on the interior or exterior surfaces of the pipe. The slots shall be machine cut having not more than 1.6 mm width. The width of the slot shall be dependent on the particle sizes of the sand. The open area of slotted casing shall be as approved by the Engineer-in-Charge. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe. The openings shall be free from jagged edges irregularities or anything that will accelerate or contribute to clogging or corrosion.

27.1.3.3 FABRICATION

The depth of pump housing pipe will be established by the Engineer-in-Charge depending on the future water levels and draw down anticipated. Length of the specified diameter of steel pipe shall be provided to extend the pump housing/casing from the elevation of the top of the pump housing pipe to the depth established by the Engineer-in-Charge.

Adjoining sections of Mild steel pump housing pipe shall be assembled by field welding. The ends of the casing sections shall be lathe turned or other-wise prepared for joining. All fields welding shall be performed by the electric arc method, using heavily coated welding rods suitable for all position welding. After being welded, the welds shall be cleaned of slag and shall show uniform smooth surface without over- lap, porosity and clinker. The pump housing pipe shall be connected to the tube-well casing (slotted and blind pipe) by means of a concentric tapered reducer.

The length and sizes of tube-well casing (slotted and blind pipe) to be installed shall be specified for the tube-well by the Engineer-in-Charge and shall be sufficient to extend from the bottom of the housing pipe to the top of the bail plug. Bail plug shall be provided at the bottom of the tube-well casing. The tube-well casing shall consist of sections for installation opposite water yielding formations and plain pipe sections or bail plug opposite non-water yielding formations as directed by the Engineer-in-Charge.

27.1.3.4 INSTALLATION

The Contractor shall install the entire pump housing and tube-well casing assembly straight, plumb, and concentric in the drilled hole to permit the installation of the pump in such a manner that it will operate satisfactorily and without damage. The methods employed by the Contractor in the installation of the casing and in obtaining or correcting the verticality & straightness of the pump housing/ casing shall be subject to the approval of the Engineer-in-Charge. Centralizers, spacers or other suitable devices shall be attached to the tube-well casing so that it will be cantered in the drill hole throughout its entire length and held in such position while gravel shrouding is being placed. Centralizers shall be attached to the pipe in a manner that ensures that the pipe is accurately cantered in the drill hole. The detailed design of centralizers and the method of attachment to the pipe shall be subject to the approval of the Engineer-in-Charge. Unless otherwise directed centralizers shall be spaced not more than 60 ft. along the overall length of screen and casing assembly.

The Contractor shall install the pump housing casing so that the deviation of its axis from the vertical shall not exceed 4 inches (100 mm) at the bottom of the pump housing casing. Measurements for determination of verticality and straightness of the pump housing casing shall be made by the Contractor in the presence of the Engineer-in-Charge upon completion ofthe gravel shrouding.

Straightness shall be determined by lowering a section of pipe 40 ft. long or a dummy of the same length to the bottom of the pump housing casing. The minimum diameter of the pipe or dummy shall be 1 inch less than the inside diameter of the pump housing casing. If a dummy is used, it shall consist of a rigid spindle with three cylindrical rings, each ring having a height of at least 12 inches. The rings shall be true cylinders and shall be located at each end and in the centre of the dummy. The central shaft of the dummy shall be rigid so that it will maintain the alignment of the axis of the cylindrical rings. The pump housing casing shall be sufficiently straight so the pipe or dummy can be passed freely throughout the entire length of the pump housing casing. Plumbs, pipes and dummies used in these tests shall be approved by the Engineer-in-Charge.

Any tube-well failing to meet the specified requirements for straightness, verticality and concentricity shall be abandoned, and the Contractor shall construct a new well at his own expense at an alternative site designated by the Engineer-in-Charge.

After completion of installation of the pump housing casing and approval of the installation by the Engineer-in-Charge, the Contractor shall paint the letter and number designation of the tube-well on that portion of the pump housing casing which projects above the ground surface. All paint, brushes, stencils and other materials required shall be furnished by the Contractor. The characters shall not be less than 6 inches shall be painted with lines I inch wide, and shall be positioned on the casing in accordance with the Engineer's instructions.

27.1.4 GRAVEL SHROUDING

27.1.4.1 GENERAL

Gravel shrouding shall consist of all work required in connection with supply and placing of gravel shrouding in annular space between the walls of the drilled hole and the outside of the pump casing. The work shall include, but not limited to development of source, excavation, stock piling, grading, washing, storing, transporting and placing of' gravel shrouding as specified herein or as directed by the Engineer-in-Charge.

27.1.4.2 GRAVEL SOURCE

The Contractor may obtain gravel from any source or location subject to the approval of the Engineer-in-Charge provided that the gravel meets the requirements of the specifications. The Department will not be responsible for the amount of work involved or the amount of materials wastage in order to obtain the required amount of gravel of proper gradation.

27.1.4.3 SPECIFICATIONS

The gravel shrouding shall be clean, washed, water worn, hard, well rounded of siliceous material, without flaky particles, free from gypsum and shale, and under no circumstances shall contain > 5% calcareous material. The gravel supplied shall be subject to inspection and screening in the field to ensure proper gradation suitable to the formation. The gravel shall be reasonably graded and shall conform to the following requirements or as specified by the Engineer-in-Charge.

U.S. Standard Screen Number	Percentage Passing
1 cm (3/8 inches)	100
No. 4	75 – 100
No. 8	35 – 65
No. 14	05 – 30
No. 16	00 – 15
No. 35	00 – 00

27.1.4.4 PLACING OF GRAVEL

Gravel shall be placed at constant rate using tremie pipe, hoppers or other similar devices to provide a continuous and uniform gravel flow so as to minimize segregation of particle sizes. When tremie pipe or hoppers are used, gravel shall be introduced in the annular space between the pump housing and the edge of the hole at two points located 180 degree apart. The tremie pipe, when used, shall be of suitable size and lowered to the bottom of the well on two opposite sides of the bore hole and calculated quantity of gravel .shall be poured in the pipe through a funnel and the pipe shall be raised by 6 ft. (1.80 meters) interval. In all cases water shall be circulated steadily during gravel placement by inserting the drilling rod into pump housing and operating the circulation pump on the drilling rig. The water level in the annular space outside the pump housing shall be maintained at or above natural surface level by return flow from the cutting bit. Temporary casing, if used, shall be carefully withdrawn in 6 ft. to 10 ft. (1.5 m to 3.0 m) interval during placement of gravel shrouding and the gravel shall be introduced so that each stage of the hole above bottom of the casing is completely filled before the casing is withdrawn to the next stage. The process of placement of gravel shrouding and withdrawing the temporary casing shall be continued to the ground level or upto level approved by the Engineer-in-Charge. As guidance the process of shall be continued until the bottom of temporary casing is at least 10 ft. above top of the topmost screen. Above this point temporary casing shall be removed or left at the option of the Contractor provided that no payment shall be made to the Contactor for temporary casing left in place except when it is of new material and is an acceptable substitute for an appropriate length of pump housing casing.

27.1.5 GROUTING OF PUMP HOUSING CASING

27.1.5.1 GENERAL

Grouting of pump housing casing shall cover providing all equipment, labour and doing all work required to seal the annular space between the pump housing casing and the bore hole face by the introduction of grout as specified herein and on the drawings according to procedures approved by the Engineer-in-Charge.

27.1.5.2 MATERIAL

The grouting operation shall be done with 1:2 cement sand mortar. Cement and sand shall conform to the requirements of Section 5 – Plain & Reinforced Concrete.

27.1.5.3 PLACEMENT OF GROUTING MATERIAL

The grout may be placed by either the tremie method or by being pumped into place provided that both the method and the type of grout is approved by the Engineer-in-Charge prior to the start of the operation.

If the tremie method is selected and approved, the grout material shall be placed by tremie pouring, (after water or other drilling fluid has been circulated in the annular space of tremie pipe sufficient to clear obstructions). The tremie method shall be used where there is a minimum annular space of 3 inches (75mm) only between the outer surface of the pump housing pipe and the inside surface of either the external casing or the bore hole. The minimum size of tremie pipe utilized shall be 2 inches (50mm) inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be 3 inches (75mm) inside diameter. When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure, with the discharge end of the tremie pipe continuously submerged in the grout until the zone to be grouted is completely filled. The minimum curing time before construction may be resumed is 72 hours.

If the method of grout placement selected and approved is by pumping, the grout shall be injected (after water or other drilling fluid has been circulated in the pumping pipe sufficient to clear

obstruction) in the annular space between the inner casing and either the outer casing or the bore hole. The annular space must be minimum of 1 ½ inches (37mm) for sand and cement or neat cement grout, and not less than three times the size of the largest coarse aggregate used. The grout pipe shall extend from the surface to. the. bottom of the zone to be grouted. The grout pipe shall have a minimum inside diameter of 1 inch (25mm) for sand cement or neat cement grout, It shall have a minimum diameter of 1 ½ inches (37mm) for concrete grout.

Grout shall be placed, from bottom to top, in one continuous operation. The grout pipe may be slowly raised as the grout is placed but the discharge end of the grout pipe must be submerged in the emplaced grout at all times until grouting is completed. The grout pipe shall be maintained full, to the surface at all times until the completion of the grouting of the entire specified zone. In the event of interruption in the grouting operation, the bottom of the pipe should be raised above the grout level and should not be re-submerged until all air and water have been displaced from the grout pipe and the pipe flushed with clear water. Curing time before construction may be resumed shall be minimum of 72 hours.

27.1.6 DEVELOPMENT AND TESTING

27.1.6.1 GENERAL

Development and testing shall consist of all work including power supply required in connection with the development of the tube-well to produce the design capacity of sand free water with a minimum drawdown, and the testing of the tube-well to determine the effectiveness of the development operations as specified herein. Development and testing shall include, but not be limited to surging, back washing and pumping the tube-well at higher than rated capacity, testing the tube-well for specific capacity, sand content and degree of development, and disinfection and sealing of the tube-well.

The Contractor shall be required to sound the well to determine wheather excess sand has accumulated at the bottom of the well at the following stages of the work;

a) On completion of the casing and screen installation
b) Before the starting of the development and
c) After completion of development and testing

If it is found at any stage mentioned above that the well contains more than 3 ft. of sand or other material in the bail plug, the Contractor shall clear the well down to a level approximately 3 ft. above the bottom plate of the bail plug.Water obtained in development and testing shall be disposed of by the Contractor in an approved manner.

27.1.6.2 DEVELOPMENT

The development procedure and methods used for development of the tube-well shall be established by the Contractor subject to approval by the Engineer-in-Charge and the development operations shall be witnessed by the Engineer-in-Charge from their initiation to their completion. The Contractor shall maintain a complete record of the development operation and shall make regular periodic measurements of discharge rates, sand content and water level measurements.

The procedures used shall include backwashing and pumping at 1.5 times the rated capacity and may include surging or similar procedures determined by the Contractor. The Contractor shall notify the Engineer-in-Charge following the completion of the 6 hours pumping, period that the tube-well is ready for testing. In wells where bentonite or other formation stabilizing agents are used, the Contractor shall undertake a programme of cleaning the well with phosphates or other dispersing agents in a manner and with chemical dosages as approved by the Engineer-in-Charge prior to starting normal development work.

27.1.6.3 TESTING

The contractor shall test each tube-well under the direction of the Engineer-in-Charge as described herein. Upon completion of the development operations the tube-well shall be permitted to recover for a minimum period of one hour. During this recovery period, the tube-well shall be sounded. If the comparison of the depth by sounding and the length of the casing string indicates that there is more than 6.00 feet of material in the tube-well, it shall be cleaned to within 2.0 feet of the bottom of the casing by bailing.

At the end of the first five minutes of pumping, the sand content of the water shall be determined by using a 40 inches Imhoff cone or other device approved by the Engineer-in-Charge. The sand content of the water at this time shall be less than 100 mg/litre. A second sand content determination shall be made 10 minutes after the start of pumping. The sand content at this time shall be less than 30 mg/l. If the sand content tolerances are exceeded at this time, or at any subsequent time upto the time of final acceptance of the installation, sand content determinations, water level, and discharge measurements during the remainder or the one hour sand test period shall be made as directed by the Engineer-in-Charge.

When the sand test has been satisfactorily completed, the tube-well shall be further developed for 4 hours by surging and backwashing with the test pump at five to ten minute intervals. Following the development period, the tube-well shall again be pumped for a period of one hour during which time the sand test shall be repeated. The specific capacity of the tube-well shall be determined from the water level measurements and flow rates obtained, during the pumping periods. If the specific capacity obtained from the second pump test is found to be more than 10 percent greater than that obtained in the first pump test, the development shall be continued as directed by the Engineer-in-Charge.

Upon satisfactory completion of the above one hour pumping period the tube-well shall be permitted to recover for a period of one hour. Upon the completion of this recovery period, a four hour multiple step pump test shall be performed by pumping the tube-well for one hour at each of approximately four equal increments.

27.1.6.4 SUMMARY

The following is a short summary of the development and testing procedure:

Development	
Development time by air lift Development tool or/and Development by pumping	2 hours (minimum)
Testing	
Recovery	1 hours (minimum)
Pumping Period(Sand Test)	1 hour
Development	3 hours
Pumping period(Retest)	1 hour
Recovery	2hour (minimum)
Step pumping	4 hours (one hour each of the rated capacities 35%, 70%, 105%, & 140%)
Pumping period (Constant discharge test)	2 hours

27.1.6.5 EQUIPMENT

The Contractor shall furnish all necessary equipment for testing the tube-well, including a water lubricated or oil lubricated test pump, a valve for fine adjustment of the discharge, an electric measuring device to determine the drawdown during each stage of the test and Imhoff cones to measure sand content. If oil lubricated test pumps are used, the contractor shall exercise all reasonable precautions to keep the leakage of lubricating oil into the tube-well at a minimum and shall promptly remove all oil which collects on the water surface in the tube-well by the addition of detergents or other suitable chemicals proposed by Contractor and approved by the Engineer-in-Charge and pumping the emulsified oil from the tube-well. In the event the Contractor fails to keep the leakage of oil into the tube-well within acceptable limits or to promptly remove oil accumulations from the tube-well, the Engineer-in-Charge will order the use of oil lubricated test pumps discontinued and the Contractor shall use water lubricated pumps for testing of the tube-wells. The actual depth of setting for the test pump will be determined by the Engineer-in-Charge after the tube-well has been developed. Piping, gauges, orifices, meters, wire boxes or other measuring devices shall be furnished, installed and removed by the Contractor and will remain his property. All measuring devices and testing equipment shall be subject to approval by the Engineer-in-Charge.

27.1.6.6 MEASUREMENT AND DATA

The Contractor shall take drawdown and discharge measurements and other pertinent data during each test at intervals as specified by the Engineer-in-Charge. All such data shall be recorded on forms approved by the Engineer-in-Charge, and the original of such forms shall be delivered to the Engineer-in-Charge at the completion of the development and testing operations.

27.1.6.7 DISINFECTION

After development and testing of the tube-well has been satisfactorily completed, and when approved by the Engineer-in-Charge, the Contractor shall disinfect the tube-well by dispersing chlorine solution throughout the entire depth of the well to obtain a minimum chlorine content of 50 mg/l. The procedure and equipment used to introduce and disperse the chlorine in the tube-well shall be subject to approval by the Engineer-in-Charge.

27.1.6.8 SEALING

Upon completion of the tube-well the Contractor shall seal the tube-well with a ¼ inch thick steel plate cap welded to the pump housing at few points using Arc welding, or by some other method approved by the Engineer-in-Charge. Compliance with this requirement will not relieve the Contractor of his responsibility for the safeguarding of any part of the tube-well completed until the Certificate of Acceptance is issued for the entire tube-well installation.

27.2 TUBE-WELL PUMPING FACILITIES

27.2.1 SCOPE

The work shall consist of furnishing, installing and commissioning deep well turbine pumps involving all mechanical and electrical works and construction of pump houses in accordance with these specifications and in reasonably close conformity with drawings and specifications and as established by the Engineer-in-Charge.

27.2.2 MATERIALS AND CONSTRUCTION REQUIREMENTS

Materials and construction requirements shall conform to those for Civil, Mechanical and Electrical Works.

Depending upon the strata, it is likely that the design of tube-well will require certain changes in the deep-well turbine pumps. Under such a deviation from the provisional design shown on the Drawings, capacity of motor (below or excess of the specified) shall form the 'basis for measurement and payment of such a deviation.

The installation, testing and commissioning of turbine pumps shall be strictly in accordance with the instructions of the manufacturer of such machinery.

27.2.3 CIVIL WORKS

Building for the pump house, fences and gates shall be constructed in accordance with the relevant specifications and Drawings or as directed by the Engineer-in-Charge.

27.2.4 MECHANICAL WORKS

(a) **General**

The work shall consist of providing, installing & commissioning pumps. motors and accessories, furnishing all plant, labour, equipment, appliances and materials, and in performing all operations in connection with mechanical works in strict accordance with the specifications and the applicable drawings and subject to the terms and conditions of the contract. Equipment damaged by the Contractor during the course of installation shall be repaired or replaced by the Contractor at his own expense.

(b) **Approval of Materials and Equipment**

As soon as practicable and within 30 days after receipt of notice to proceed and before any material or equipment is purchased, the Contractor shall submit, for approval by the Engineer-in-Charge a complete schedule, in triplicate, with the names and addresses of the manufacturers and their catalogue cuts, diagrams, drawings, and such other descriptive data as may be required by the Engineer-in-Charge. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under this provision shall not be construed as authorizing any deviations from the specifications unless the attention of the Engineer-in-Charge has been directed to the specific deviations.

(c) **Material and Equipment**

Materials and equipment shall conform to the respective specifications and other requirements specified hereinafter and shall be new and unused.

27.2.5 WATER PUMPS

Pumps shall be of the open line shaft water lubricated vertical turbine type for installation and operation in tube-wells and shall be suitable for use with vertical, hollow-shaft, squirrel cage induction type motors. All pumps shall consist of pump bowl assembly, column pipe, line shaft and surface discharge head assembly, including water pre-lubrication system as required and all other parts and appurtenances to provide a complete operating pump in accordance with these specifications.

(a) **Design**

The material, design, fabrication and assembly of equipment shall be in strict accordance with American Water Works Association Standard A 101-61 Entitled" American Standard for Vertical Turbine Pump", or latest revision and the following requirements:

(i) **General**

Water Pumps shall be vertical shaft centrifugal pumps with rotating impellers and discharge from the. pumping elements coaxial with the shaft. The pumping element shall be suspended by the conductor system which encloses a system of vertical shafting used to transmit power to the impellers, the prime mover being external to the flow stream. The basic pump shall consist of the following three elements:

Pump Bowl Assembly

The pump bowl assembly shall be either a single or multistage, centrifugal vertical pump with discharge coaxial with the shaft.

Column and Shaft Assembly

The column and shaft assembly shall consist of the column pipe which suspends the pumps bowl assembly from the head assembly and serves. as conductor for the fluid from the pump bowl assembly to the discharge head. Contained within the column pipe shall be the line shaft which shall transmit the power from the driver to the pump shaft. The line shaft shall be supported throughout its length by means of bearings which are lubricated with water.

Head Assembly

The head assembly shall consist of the base (from which the column and shaft-assembly and the bowl assembly shall be suspended) the discharge head which directs the fluid into the desired piping system and the driver.

(ii) **The Driver Coupling**

The driver coupling is the mechanism, which transmits the power to the top shaft. It shall contain means for impeller adjustment and provide a bearing to carry the thrust load.

(iii) **Discharge Head**

A cast iron flange shall be integrally cast on the discharge head. The discharge flange shall have a companion flange suitable for connection to the discharge pipe.

(iv) **Motor Mounting Flange**

The motor mounting flanges of pumps shall match the NEMA flanged base plates of motors and base plates of right angle gears.

(b) **Manufacture**

The pumps shall be those manufactured by M/s KSB or equivalent of the types as specified. The pumps shall be manufactured to meet the characteristics specified on the drawings or as directed by the Engineer-in-Charge.

(i) **Pump Element**

The impellers shall be the enclosed skirt seal type constructed of bronze meeting the requirements of ASTM Standard B 145-61 titled "Leaded Red Brass and Leaded Semi-Red Brass Sand Casting". Impellers shall be accurately fitted, smoothly finished, and dynamically balanced at the normal pump speeds. The bowls shall be constructed of close-grained cast iron. The inside of each bowl shall be hand finished to mirror-like smoothness. Three or four stage pumps as approved by the Engineer-in-Charge shall be supplied by the Contractor. Each suction bowl shall be fitted with a grease-packed bronze bearing and suction case plug. A suction case and collar shall be provided to protect the bearings. Each pump bowl shall have a fluted rubber bearings above each impeller and shall be designed for the future installation of bronze or cast iron wear rings.

Each discharge bowl shall be equipped with a bronze bearing. The pump and line shaft shall be of stainless steel conforming to ASTM Standard A 276-60 entitled Hot-Rolled and Cold-Finished Corrosion Resisting Steel Bars", type 416, and shall be of suitable size to transmit the loads and to maintain correct alignment without distortion or vibration. The pump shaft shall be turned, ground and polished and shall be threaded for connection to the line shaft.

(ii) **Column Pipe and Line Shaft**

The column pipe shall be furnished in interchangeable sections having a normal length of 10 feet. Wall thickness shall be minimum 0.234 inches. . The ends of each column pipe section shall be faced parallel and perpendicular to the axis of the pipe. The threads shall be machined so that adjoining sections of column pipe will butt together to ensure proper alignment on assembly. The line shaft shall be ground carbon steel shafting in accordance with ASTM Standard A 108-61T entitled "Cold Finished Carbon Steel Bars and Shafting" Grade 1020 or 1045 and shall be furnished in interchangeable sections having a nominal length of 10 feet. The ends of the shaft sections shall be faced parallel and perpendicular to the axis of the shaft. Adjoining sections of the line shaft shall

be connected by means of threaded, sleeve-type couplings of the same material as shall be supported by fluted, oil resistant, rubber bearings designed to be lubricated by water. The bearings shall be mounted in bronze bearing retainers which shall be threaded into the column couplings and butted against the adjoining section of column pipe. The rubber bearing shall be replaceable within the bronze bearing retainers and shall be spaced at intervals of not more than 10 feet along the line shaft.

(iii) **Surface Discharge Head**

Each surface discharge head shall be of the above ground type and shall be a suitable base for supporting the specified electric motor and the pump column. The discharge head shall be of cast iron conforming to ASTM Standard A 48-62 titled "Standard Specification for Grey Iron Casting" Class 30 A or an approved equal quality of casting. Each surface discharge head shall be furnished with an integral ASA 125 pound flange conforming to ASA B16-1-1948 "Cast Iron Pipe Flanges and Flanged Fittings, Class 125". The discharge heads shall include half couplings connecting to discharge pressure and suction pressure to accommodate gear cooling water lines as required by the gear drive unit.

(iv) **Pre-lubrication System**

The contractor shall furnish a manually operated water pre-lubrication system complete with all valves piping and storage tank for the turbine pump. The piping for pre-lubrication system shall be complete with necessary valves, lines and fittings to permit filling of the pre-lubrication tank from the pump discharge and to permit the water to be manually released prior to starting pump. The pre-lubrication tank shall be an enclosed tank of sufficient size to adequately lubricate the line shaft bearing before pump start-up and shall be equipped with an opening in the top through which it may be filled from the pump discharge or from an outside source.

(c) **Quality Control Tests**

The manufacturer shall perform all the quality control tests as specified hereafter and all test results and anticipated field performance curves shall be submitted in triplicate, to the Engineer-in-Charge.

(i) **Standard Running Test**

The pump bowl assembly shall be operated from zero capacity to the maximum capacity shown on the performance curve submitted with the manufacturer's bid. Readings shall be taken at a minimum of 5 capacity points, including one point within $\pm$ 2% of design capacity specified. The pump shall be operated at a speed within $\pm$ 5% of the design speed.

(ii) **Capacity Measurement Test**

The capacity of the pump shall be measured by means of a standard venturi tube, nozzle orifice plate or pilot tube traverse.

(iii) **Head Measurement Test**

For head measurement in excess of 36 ft. calibrated bourdon or other gauges with equivalent accuracy and reliability shall be used. All gauges shall be calibrated before and after each series of tests.

(iv) **Test for Velocity**

The average velocity in the pump column used to determine the velocity head shall be calculated from dimensions obtained by actual measurement of the pipe and shaft or enclosing tube diameter and the velocity head shall be obtained from actual measurement of the inside diameter of the discharge pipe at the point where the pressure tap is located.

(v) **Horsepower Input Test**

The power input to the pump shall be determined with vertical dynamometer or a calibrated electric motor. Calibrated laboratory type electric motors and transformers shall be used to measure the power input to all motors.

(vi) **Measurement of Speed**

The rotating speed of the pump shall be obtained by a hand counter, electronic computer or a counting slip.

(vii) **Hydrostatic Test**

A standard hydrostatic test on the pump bowl assembly shall be made at 1 ½ times the shutoff head developed by the pump bowl assembly or at twice the rated head, whichever is greater.

27.2.6 MOTORS

a) Pump Motors

The pump motors shall be vertical hollow shaft fan coated totally enclosed weather protected squirrel cage, induction type and shall have 4 poles with approximate speed of 1460 rpm on 400 volts, 3 phase. 50 cycle. The motor horse power for each site shall be indicated in the Bill of Quantities. When operating continuously at full rated load, the temperature rise shall not exceed 40 degree centigrade above an ambient temperature of 50 degree centigrade. The motor shall have a service factor of 1.15 times the rated horsepower and horsepower loadings shall not exceed the name plate at any point on the pump performance curve. The motors shall conform to NEMA Standard MG 1, titled "Motors and Generators" for a class B design and shall have low starting current and normal starting torque. The locked rotor input shall not exceed 5.6 KVA per horsepower. The winding shall have Class B insulation and shall be suitable for operation under conditions of high humidity and at an ambient temperature of 55 degree centigrade. Each motor shall be equipped with three thermal devices embedded and symmetrically spaced in the stator winding. These devices shall operate on temperature rise to de-energize the control circuit of the motor thus disconnecting it from the power source. The thermal devices shall be so located in the winding and so constructed that they will prevent motor damage due to overheating resulting from overload, lack of ventilation, single phasing, stalling, high ambient temperature or Voltage imbalance. The pump motors shall be designed for mounting on the surface discharge, head and for direct connection to the line shaft. A thrust bearing of adequate capacity to carry the weight of all rotating parts, plus the hydraulic thrust shall be provided on each motor. The motors shall be provided with a completed oil or grease lubrication for each bearing. Each motor shall be provided with a non-reverse ratchet to prevent reverse rotation of the pump.

(b) Motor Control

The motor controls for each motor shall consist of motor starter and control switches with all necessary components for a complete installation. Each motor control shall be suitable for controlling and protecting 400 volts. 3 phase 50 c/s electric motor. Motor controls shall be furnished in complete accordance with the applicable provisions of NEMA Standard 1 CI, entitled “Industrial Controls". shall have a minimum insulation level for 600-volt class equipment, and shall be designed to provide short circuit protection in all phases and overload protection in all three phases. The thermal overload relay reset device shall be mounted to be opera table without the necessity of opening the casing. Each motor control shall be furnished complete as a unit with all component parts and accessories completely wired to conform to NEMA Class-II construction, Class-B wiring. The conductor shall be 600 volt. heat resistant, thermoplastic insulated wire suitable for 75' operating temperature. A weather proof enclosure NEMA Type-III with a lockable outer door, shall be provided.

27.2.7 PIPING

Piping for mechanical equipment shall be accomplished as indicated and shall conform to the relevant specification in the following Section 27.3 covering “PIPES, PIPE LAYING AND APPURTENANCE”.

27.2.8 INSTALLATION

Installation shall include all bolts, nuts, washers, shims, fittings, grout and other materials required for proper installation of the equipment which are not supplied as part of the equipment. Equipment damage during the course of installation shall be repaired or replaced by the Contractor at his own expense.

a) Pumps and Motors

The Contractor shall carefully clean, assemble, align and install the pumps in accordance with the manufacturer's recommendations. Care shall be taken that all connections are clean and free from burrs and foreign material so as to ensure tight fit and proper alignment. Connections between adjoining sections of column pipe and line shaft shall be correctly assembled and tightened to maintain accurate alignment. A suitable thread lubricant shall be used on all threaded connection to facilitate disassembly for maintenance. The pumps and motors shall be installed in tube-well in accordance with the manufacturer's instructions. The surface discharge heads shall be accurately set on the concrete pump platforms shown on the drawings and shall be aligned with pump housing casing. The surface discharge heads shall be rigidly connected to the reflux (check) valve and the dresser-type couplings. All the fittings shall be properly installed as shown on the drawings. In order to ensure the accurate and proper alignment of the pump, anchor bolts shall set only after the pump has been set and aligned. Anchor bolt holes may be formed in the concrete platform as the concrete is placed or may be drilled in the concrete after the concrete has set thoroughly. The anchor bolts shall be minimum 5/8 inch diameter and minimum 12 inches long with nut and lock washer, and shall be set in the anchor bolts holes with sufficient extension to permit the fun threads of the nuts to be engaged by the anchor bolt. The anchor bolts shall then be set in cement grout. Where holes are drilled after the concrete has set thoroughly, expansion bolts or lead expansion anchors may be installed at the option of the contractor in lieu of grouting anchor bolts. Non-shrink grout shall be placed under the entire surface of the discharge head to provide proper support for the pump. Non-shrink grout shall conform to the applicable requirements set forth in the Specifications for concrete.

27.2.9 ELECTRICAL WORKS

The work shall consist of furnishing all plant, labour, equipment, appliances, and materials and in performing all operations in connection with the electrical work in strict accordance with the applicable specifications, Section 30 – Electrical Works and the drawings, and subject to the terms and conditions of the Contract Agreement.

27.2.10 CHLORINATION EQUIPMENT

(a) Chlorinator

Chlorinator shall be of vacuum solution feed, manually set cylinder mounted type. Chlorinator shall be capable of meeting requirements of water flows ranging from 1cusecs to 2 cusecs and delivering upto 1 lb/hr. of chlorine gas in solution to give a maximum dosing rate of 2 ppm. The chlorinator shall be supplied complete with all standard accessories and complete in all respects to ensure satisfactory operation.

(b) Chlorinator Accessories

The chlorinator should include among its accessories an injector. a water booster pump with electric controls, a chlorine gas inlet connected via pressure regulating valve, a linear feed rate indicator, a feed rate adjuster, a pressure relief valve, a drain relief valve, and chlorine pressure gauge.

(c) Booster Pump

The Contractor shall supply along with each chlorinator a water pump for booster water pressure to meet, requirement of the chlorinator. The pumps shall have adequate pumping capacity and to ensure proper mixing of chlorine and water in the injection assembly of chlorinator. The pumps shall be electrically driven by single phase motor capable of operation on 220 V, 50 hz. with ±10% fluctuation in voltage. The pumps shall be supplied complete with suction and delivery isolating valves. check valves, pressure gauge and appropriate starters.

(d) Empty Gas Cylinders

The Contractor shall supply with each chlorinator two 150 lb. empty chlorine cylinder designed and fabricated in accordance with AWWA or A.S.T.M. Specifications or equivalent. The welded seams shall be fully stress relieved after fabrication. A corrosion Allowance of 1/16 inch shall be provided for the design thickness of the cylinders. Material of construction shall be according to ASTM A-515 Grade 60 or ASTM A -285 Grade C or equivalent.

Cylinder shall be provided with matching outlets corresponding to chlorinator offered under this Contract. Each cylinder shall also have a protection cap provided along-with the cylinder.

27.2.11 GUARANTEE

Equipment furnished shall be guaranteed for a period of one year from date of acceptance hereof against defective materials, design, and workmanship or as stated in the Contract. Upon receipt of notice from the Engineer of failure of any part of the guaranteed equipment during the guarantee period, new replacement of part or parts of same trade mark as provided originally shall be furnished promptly by the Contractor at no additional cost to the Department.

a) Operation and maintenance Manual

The Contractor shall furnish 6 copies of an illustrated operation and maintenance manual with each piece of equipment furnished under this section.

b) Spares and Tools

The Contractor shall furnish common spares such as O-rings, bushing, bearing, other similar items and special tools for each piece of equipment furnished under this section for its efficient service for over 3 years period.

27.3 WATER SUPPLY

27.3.1 MATERIALS

27.3.1.1 PIPES

Material of the water supply pipes shall conform to the respective specifications and other requirements specified hereinafter. The pipes shall be new and unused unless otherwise specifically specified or directed by the Engineer-in-Charge. The standard length of pipes of each material as specified shall be used.

a) Cast Iron Pipes and Fittings

Cast iron pipes and fittings shall comply with ISO 13-1978 (E) or B.S. 78 for spigot and socket vertically cast pipes, B.S.1211 for spigot and socket spun iron pipes and B.S. 2035 for flanged pipes.

b) Asbestos Cement pipes, Fittings and Specials

These shall conform to International Organization for Standardization Recommendation R160 "Asbestos Cement Pressure Pipe and joints" or British Standard Specification 486 "Asbestos Cement Pressure Pipe" or to Pakistan standard specification No. PS. 428 : 1984 of the class capable of withstanding a 400 ft. head test pressure. Short lengths of pipe machined overall shall be used at fittings for tying in the fittings and specials for asbestos cement pipes shall be cast-iron conforming to British Standard Specification 78: PART 2 Fittings: "Cast Iron Spigot and Socket Fittings", Class AV, except that the fittings and specials shall have the shapes, dimensions and tolerance required to fit the asbestos-cement pipes.

Rubber ring shall conform to Pakistan Standard Specification No. PS. 1915: 1987.

c) Galvanized Iron Pipes and Fittings

The galvanized iron pipes shall conform to B.S. 1387 Specifications for "Steel Tubes and Tubular suitable for screwing to B.S. 21 pipe threads" and shall be of medium grade. All screwed pipes and sockets shall conform B.S. 1740. A complete and uniform adherent coating of zinc white will be provided for galvanized iron pipes and fittings.

d) M.S Pipe

All mild steel pipes shall conform to ASTM designation A53, Schedule 40 "Standard Specification for Welded and Stainless Steel Pipes". All pipes shall be internally cement mortars lined and externally bituminous coated. M.S. short pieces shall be flanged at both ends. The flanges shall conform to B.S. 4504, part 3 (PN 16). M.S. pipe pieces shall be externally protected by applying two coats of red oxides (of approved quality) and bituminous coating (grade 10/20) at the rate of 0.4 lb/Sq.ft.

e) Un-plasticized Polyvinyl Chloride Pipe and Fittings

Un-plasticized polyvinyl chloride (uPVC) pipe and fittings if approved by the Engineer-in-Charge shall confirm to BS 3505. The pipes shall be class B. The pipes and fittings shall not be stored directly exposed to sunlight handled or laid in conditions where ambient temperatures may cause distortion or damage. In extreme conditions, pipes and fittings may have to be stored under water.

f) Joints for Un-plasticized Chloride Pipe

Joints for un-plasticized polyvinyl chloride pipe shall be the Z type consisting of a socket with rubber gasket, or approved equal, and assembled in accordance with the pipe manufacture’s recommendations.

g) Ductile Iron Pipes and Fittings

Ductile iron pipes shall be made from a suitable spheroid graphite iron centrifugally cast in lined or unlined metal moulds in conformity with the ISO Standard 2531 Class K9 or its equivalent. The pipes shall have spigot and socket ends employing elastomer gaskets for making push-on joint. Pipes with mechanical joints shall be used wherever rigidity is required and shall have flanges with appropriate nuts and bolts and the gasket. Fittings and specials shall be of ductile iron made to match the type and size of pipes. Except tees, all standard fittings shall conform to ISO Standard K12 whereas tees shall conform to K14.

27.3.1.2 SLUICE (GATE) VALVE

Valves shall be wedge gate valves conforming to British Standard Specification 5163. Ends of valves shall be suitable for the type of pipe to which the valves will be connected.

27.3.1.3 CHECK VALVES

Check valve shall comply with the requirements of BS 5153 latest revision for pressure rating of 16 bar. The valve shall be of swing type and shall be of quick acting single door type.

27.3.1.4 FIRE HYDRANTS

The metal of the fire hydrant shall conform to B.S. 750 and shall be of screw down streamline pattern. The body shall be best quality, closed grain, grey cast iron with spindle of manganese bronze having tensile strength of not less than 11.0 tons per square inch(1.63 kg/mm^2) machined from solid rolled bars, the seating valves and other parts shall be of best quality gun metal with Brinell Hardness No. 80. The direction of closing shall be by clockwise rotation and outlet shall have screwed joint for accommodation 2-1/2" dia hose connection. Inlet flanges of hydrant shall be suitable for jointing with flanges of hydrant bends and tees. All fire hydrants shall be coated with three coats of solution from an approved manufacturer to give a uniform protective coating on cast iron.

27.3.1.5 SURFACE BOXES

The surface boxes shall be manufactured as per drawings. Cover and frame shall be of cast iron.

27.3.1.6 FERRULES

Brass ferrules of the sizes required shall be provided with M.S straps and cast iron saddles as approved by the Engineer-in-Charge.

27.3.1.7 APPROVAL OF MATERIALS

As soon as practicable but within 30 days after receipt of notice to proceed and before any materials or equipment are purchased, the Contractor shall submit for approval by the Engineer-in-Charge a complete schedule, in triplicate, of materials and equipment to be incorporated in the work, together with the names and addresses of the manufacturers and their catalogue cuts, diagrams, drawings, and such other descriptive data as may be required by the Engineer-in-Charge. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under deviations from the specifications shall not be granted unless the attention of the Engineer-in-Charge has been directed to the specific deviations. Laboratory results and certifications, specified or otherwise required, shall be submitted prior to delivery of the material and equipment to site.

27.3.2 INSTALLATION

27.3.2.1 HANDLING

Pipe and accessories shall be handled in such a manner as to ensure their delivery to the trench in sound, un-damaged condition. If any pipe or fitting is damaged, the repair or replacement shall be made by the Contractor at his expenses in a satisfactory manner. No other pipe or material of any kind shall be placed inside of a pipe or fittings. Pipe shall be carried into position and not dragged. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material at the cost of the Contractor. Rubber gaskets that are not to be installed immediately shall be stored in a cool dark place and protected against the direct rays of the sun.

27.3.2.2 CUTTING OF PIPE

This shall be done in a neat and workman-like manner without damage to the pipe. Unless otherwise authorized by the Engineer-in-Charge or recommended by the manufacturer, cutting shall be done with a mechanical cutter of approved type. Wheel cutters shall be used wherever practicable.

27.3.2.3 LOCATION

Where the location of the water pipe is not clearly defined by dimensions on the Drawings, the water pipe shall be located as directed by the Engineer-in-Charge.

27.3.2.4 EXCAVATION IN TRENCHES AND BACKFILLING

The trenches shall be set out to suit alignment of the pipe lines. The trenches shall be carefully trimmed at sides and bottom of that pipe lines when laid shall rest on the firm bed throughout the length. Shallow joint holes shall be left for the joint, where necessary. Where pipe line is to be laid in plains the depth of cover, i.e., the normal distance from ground level to the top of the pipe be kept at about 800 mm and shall not be less than 750 mm except due to special reasons where the Engineer-in-Charge directs in writing to the contrary.

27.3.2.5 PLACING AND LAYING

Pipe and accessories shall be carefully lowered into the trench by means of derrick ropes, belt slings, or other suitable equipment. Under no circumstances shall any of the water line materials be dropped or dumped into the trench. Care shall be taken to avoid abrasion of the pipe coating. Poles used as levers shall be of wood and shall have broad flat faces to prevent damage to the pipe. Except where necessary in making connections with other lines or authorized by the Engineer-in-Charge pipe shall be laid with the bells facing in the direction of laying. The full length of each section of pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bell coupling and joints. Pipe that has the grade or the joint disturbed after laying shall be taken out and re-laid. Pipe shall not be laid in water. The water shall be kept out of the trench until the materials in the joints have hardened or until caulking or joining is completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substances will enter the pipes or fittings. Where any part of a coating or lining is damaged, the repair shall be made by the Contractor at his expense in a satisfactory manner as approved by the Engineer-in-Charge. Pipes shall be installed in accordance with recommendations of the pipe manufacturer. Pipe ends left for future connections shall be valved, plugged or capped, and anchored, as shown on drawings or as directed, where connections shall be made by using specials and fittings to suit the actual conditions.

27.3.2.6 JOINTING

a) General

The joints shall be in accordance with the recommendations of the manufacturer or as approved by the Engineer-in-Charge.

Connections between different types of pipes and accessories shall be made with transition fittings where recommended by the pipe manufacturer.

b) Cast Iron/Ductile Iron Pipes and Fittings

The jointing could be any of the following:

Rubber Gasket Joints

Rubber gasket joints may be used for socket and spigot pipes, where called for Rubber gasket joints shall be made using specified rubber gaskets, conforming to PS-428: 1984 and ISO 160-1980 made to fit the applicable socket and spigot pipes. An approved rubber ring lubricant (but not grease), shall be used for joining the pipes. Care shall be taken to avoid contamination of the gasket and lubricated surface, with earth or other undesirable material during installation.

Lead Caulked Joints

The socket joints of the pipes and special castings shall be made with lead and white spun yarn. The joints shall be made by forcing the spigot end of one pipe into the socket end of the preceding

one. A gasket of spun yarn being then driven and caulked into the joint keeping the pipes concentric. The gasket shall either be driven in complete rings, or better still a spiral coil of yarn shall be inserted. In the former case, care shall be taken that the joints of the successive rings do not coincide. Each ring shall be packed with a thin steel "yarning" tool and then lightly hand caulked to ensure that the yarn is solidly packed. Short pieces of yarn forming less than a complete ring shall not be used. The yarn shall be caulked to such a depth as to leave clear the following depths measured from the faces of the sockets for the lead joints.

Pipe dia. (cm)	Finished Depth of Lead Joints (mm)
5 to 12.5	40
15, 18	45
20, 23	48
25, 30	50

A jointing ring shall be placed round the barrel and against the face of socket. Molten lead shall be poured in to fill the remainder of the socket. Before making any joint, care shall be taken to remove all thick bituminous material or coal tar from the spigot end and from the inside of the socket. Both shall be thoroughly cleaned and dried before the joint is made after the lead has solidified in the joint, the jointing ring shall be removed and the lead shall be caulked right round the joint to make up for the shrinkage of the molten metal on cooling. The joint shall be set back by caulking, not less than 4 mm inside the face of pipe socket.

Lead Wood Caulked Joints

This type of lead caulking shall be done where it shall be inconvenient or dangerous to use molten lead for joints for example, in cases such as inverted joints or in wet trenches. The spun yarn shall first be inserted and caulked into the socket as described under jointing with molten lead. Lead wool or lead yarn shall then be introduced in the joint in strings not less than 6 mm thick and the caulking repeated with each turn of lead wool. The whole of the lead wool shall be compressed Into a dense mass. The joint shall then be finally finished flush with face of the socket. The lead wool brought to site shall be properly protected and packed with wax paper or polythene sheet, to prevent oxidation.

Flanged Joints

These shall be made using 3 mm rubber insertion jointing discs accurately cut. The bolts of the joints are to be tightened up systematically and uniformly in such a manner that the tension in all the bolts shall be similar and there shall be no tendency to distortion. No bolt shall be stressed beyond its elastic limit.

c) G.I/ M.S Pipes and Fittings

Screwed Joints

All screwed joints, both internal and external, shall be examined before jointing, to ensure that the threads are perfect for the full depths of the joints. The jointing shall be such that the ends of pipes or Specials remain equidistant from the middle of the socket and space between them in the centre of the socket is not more than 6 mm. All burrs from the ends of the threaded joints shall be removed.

To make the joints water tight thin strands of best quality country cotton yarn smeared over carefully with genuine Red lead shall be used. A paste of genuine red and white lead mix shall be lightly smeared over the threads to act as a lubricant and to make up for imperfections in the threads when the pipes are screwed up. No red and white lead paste or cotton yarn shall project outside the ends of the joints

Flanged Joints

In the case of pipe lines laid in open country whether in trenches or on the surface, flanged joints shall be provided at intervals of not more than 500 feet. The flanges shall be screwed on to the pipes in the same manner and using the same jointing composition as already described for screwed joints so as to be water tight. All flanges shall be screwed home and the end of the pipe projecting in front of the flange faces shall be neatly cut off, filed and made perfectly smooth and not to project ahead of the faces of the flanges so as not to interfere with the accuracy of the joints. Each flanged joint shall be made by inserting an accurately cut disc of tough multiple rubber insertion about 3 mm thick of approved quality between the flanges. The bolt holes in the rubber insertion as well as in the flanges shall be, drilled to template. The bolts shall be pulled up gradually and evenly so as to ensure a perfect joint. They shall, however, not be over-strained

d) Asbestos Cement Pipes

Comete Couplings

Comete couplings manufactured in asbestos cement and provided with two jointing rings, one at each end shall be used. The rings shall be supplied by the pipe manufacturer. They shall be lip seal type conforming to P.S-1438, latest version, "Rubber sealing rings for joints in asbestos cement water piping". The joints shall not only withstand internal test pressures but also provide adequate safeguards against seepage of ground water into pipe lines.

Flanged Joints

Gaskets for flanged joints shall conform to the requirements of Standard Specifications for "Sheet Buffer Packing" (ASTM Designation: D 1300-59). Grade No.1, black colour, and thickness of 8 mm.

e) PVC Pipes

The joints in the pipe line shall be "Z" type rubber ringed joints. For jointing with specials like valves, special stub flanges and steel flanges drilled to shape and size of flange on the special fitting will be used. For jointing with CI or asbestos cement pipes special, socketed pieces or spigotted pieces or pieces with stub joints on one end and socket or spigot on the other end shall be used.

Pipes should be jointed outside on the side of trench and then lowered into prepared trench with necessary bedding already in place. Heavy fittings will be jointed in the trench. For achieving reliable and satisfactory installation, factory made fittings must be used and due consideration be given to thermal effect on PVC .and to supporting heavy fittings like valves, independently so that these do not bend or damage the pipe. On hot days the pipe should be allowed to cool off in the trench before being fixed to valves etc., so as to avoid stresses on shrinkage. Hot air in the body of pipe be released through air valves or through taps connected to saddled tappings. Use of 'Z' type joint reduces the risk of shrinkage as it allows movement. Branching shall be done by special welding process, which shall be obtained from the manufacturer and should preferably be done by his crew or by specially trained workers.

Only special jointing solution and other items like rubber rings supplied by the manufacturer shall be used. The solution should be applied uniformly, evenly and thinly. A thick layer will not improve but may weaken the joint. Only tapping saddles made from gun metal and supplied by the manufacturer of pipes will be used for making house connections. End connections with screwed GI pipes will be made with special socked and screwed connecting pieces obtained from the pipe manufacturer.

27.3.2.7 DEFLECTION

Maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets will be 2" for Asbestos Cement Pipe unless otherwise recommended by the manufacturer. If the alignment requires deflections in excess of the specified limitations special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set-forth, as approved.

27.3.3 MASONRY CHAMBERS FOR SLUICE VALVES,

Valves Fire Hydrants etc.

Masonry chambers shall be constructed according to the drawings or as instructed by the Engineer-in-Charge. The concrete and masonry work shall be according to the provision of the relevant Sections.

27.3.4 SETTING OF FIRE HYDRANTS, VALVES AND SURFACE BOXES

Fire hydrants shall be located and installed, as shown on drawings. Hydrants shall be set plumb and in accordance with the manufacturer's instructions.

Valves and surface boxes shall be installed as shown or directed, and shall be set plumb. Surface shall be centered on the stems or operators. Concrete, concrete pipe, brick, brick ballast used in chambers shall conform to the relevant clause of the Specification. Where feasible, valves or operators shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box to the satisfaction of Engineer-in-Charge on all sides of the box, or to the undisturbed trench face if less than 4 ft.

Hydrants and valves shall have the interiors cleaned of all foreign matter before installation. Surface boxes shall be lighted and the hydrant or valve shall be inspected in open and closed positions to ensure that all parts are in working condition.

27.3.5 FERRULE CONNECTIONS

Service connections to water mains shall be made either by drilling and tapping the main after the pressure has been shut off, or by use of special tapping apparatus whereby the main can be drilled and tapped and the ferrule introduced while the main is still under pressure. The later method shall be used for trunk mains or in other cases where it would be inconvenient to shut off the water while the connection is being made.In order to make a service connection to an asbestos cement water main, a malleable iron saddle piece with a flat boss shall be first bolted round the main with a rubber washer between the main and the boss. The boss and the pipe shall then be drilled and tapped together, giving a continuous thread through the boss and the wall of the main.

27.3.6 THRUST BLOCKS

Plugs, caps, tees, bends and fire hydrants shall be provided with concrete thrust blocks. Backing shall be placed between solid ground and the hydrant or fitting to be anchored. The area of bearing shall be as shown on the Drawing. The backing shall be so placed that fitting joints shall be accessible for repair. The concrete shall be 2000 psi plain cement concrete.

27.3.7 PIPE BEDDING

Fine sand as pipe bedding material shall be used for A.C. pipe and C.I. fittings. The sand shall be free from clay, site, salts, organic impurities and debris. Approval of pipe bedding materials shall be obtainedfrom the Engineer-in-Charge prior to placing.

27.3.8 PAVEMENT RESTORATION

The Contractor shall restore paved surface which have been cut, as part of the work under the excavation items and at no extra cost to the owner/employer.

27.3.9 FLUSHING

The Contractor shall provide facilities for flushing the line. Water for flushing the line shall be arranged by the Contractor. Flushing of line shall be done section by section. For each valved section of pipeline the Contractor shall make a temporary hose connection between the water pipeline and the pipeline under test. Water shall be pumped into the section flushed. Other arrangements for storing and pumping of water shall be subject to the approval of Engineer-in-Charge. Due precautions shall be taken by the Contractor for the disposal of water. The pipeline shall be flushed by keeping all the branching pipes open. Flushing shall be continued until clean water starts flowing through the other end. Section by section, the entire pipeline shall be flushed at a minimum flushing velocity of 2.5 ft./sec.

27.3.10 LEAKAGE TEST

Flushing of the pipeline shall be followed by a leakage test. The Contractor shall provide facilities for performing the leakage test. Water and pumping facilities shall be provided by the Contractor. Before the testing of pipeline the Contractor shall ensure that concrete backing blocks have been provided where necessary. The test shall be performed only after all concrete work in contact with pipe to be tested has set for a minimum of 24 hours. All joints shall be left exposed. Leakage test shall be performed by keeping the end of the pipeline closed by proper plugs blocked to resist 150 per cent of the working pressure. While filling the line all valves and openings shall be kept open and water shall be filled in slowly. When the pipeline is completely filled with water and all air expelled, water shall be pumped into the pipeline to a minimum pressure of 150 percent of actual working pressure and the test pressure shall be maintained for at least 1 hour. Each and every joint shall be inspected for leaks and for all visible leakage and displacement leakage test shall be performed by the Contractor, for the newly laid pipeline. A measured quantity of water shall be pumped into the pipeline. No piping installation will be accepted until the leakage is equal or less than the number of imperial gallons per hour as determined by the formula:

$$L = 0.00054\ ND / P$$

Where

L = Leakage in Imperial Gallons

N = Number of joints

D = Nominal diameter of pipe in inches

P = Average test pressure (psi) during test

In the event of the pipeline failing the leakage test, the Contractor shall locate and repair the defective pipe, fitting or joint at his expenses. For dewatering the line for repairs the Contractor shall follow the instructions given by the Engineer-in-Charge for disposal of water. After repairs of the line, the Contractor shall retest the line. The line will not be accepted until it passes the leakage test.

27.3.11 RETESTING AFTER BACKFILL

After the pipe trench has been backfilled, the entire length shall be subjected to a leakage test as a whole unit. The Contractor shall repair the line if it fails to pass the leakage test requirements specified hereinbefore. The test shall be repeated and repairs affected until the pipeline passes the leakage test.

27.3.12 PIPELINE DISINFECTION

27.3.12.1 GENERAL

The Contractor shall furnish all equipment, labour and material for the proper disinfection of the pipeline. Disinfection shall be accomplished by chlorination after the lines have been tested for

leakage but before they have been connected to the main system. Disinfections of the pipelines shall be done in the presence of the Engineer-in-Charge's representative with equipment approved by him.

27.3.12.2 CHLORINATION

A chlorine and water mixture shall be supplied by means of a solution feed chlorination device. The chlorine solution shall be applied at one end of the pipeline through a trap, in such a manner that as the pipeline is filled with water, the dosage applied to the water entering the pipe shall be at least (25 ppm) or enough to meet the requirements given hereinafter.

Chlorinated water shall be retained in the pipeline for a period of at least 24 hours. After the chlorine treated water has been retained for the required time, the chlorine residual at the pipe extremities and at such other representative points shall be at least 10 parts per million. This procedure shall be repeated until the required residual chlorine concentration is obtained.

During the process of chlorination the pipeline, all valves or other appurtenances shall be operated while the pipeline is filled with the heavily chlorinated water.

27.3.12.3 BY ADDING CHLORINATED LINE

Chlorinated line is dissolved in water tank and is lead into mains along with water for sufficient to ensure complete freedom from pollution. In general the following amount of chlorinated line for each 3.5 meter length of main will be sufficient.

Diameter of main (mm)	100	150	200	250	300
Chlorinated line in (mm)	10	20	40	60	85
Chlorinated line in table Spoonful	0.5	1	2	3	4

27.3.12.4 BY ADDING BLEACHING POWDER

After the main have passed the pressure test, they shall be thoroughly scoured out; and further to ensure that the pipe system is free from injurious matter, it shall be filled with solution of bleaching powder (calcium hypocholorite) or of permanganate of potash and allowed to remain there for 24 hours. After the period, the system shall again be scoured out and filled with the water of supply main.

27.3.13 FINAL FLUSHING

Following complete disinfection of the pipeline, all treated water shall be thoroughly flushed from the pipeline at its extremities. Treated water and water used for flushing the pipelines shall be disposed of in a manner instructed by the Engineer-in-Charge. Fresh treated water shall be filled in the line and water tested from presence of coliform, the test result should indicate negative coliform presence. If the test indicates any positive coliform, the entire process of disinfection shall be repeated or improved upon until coli form free samples are obtained.

27.3.14 SAMPLING AND TESTING

Disinfection of the pipeline and appurtenances shall be the responsibility of the Contractor. The first set of samples will be collected for analysis by the Engineer-in-Charge. Should the samples reveal presence of coliform the Contractor shall again disinfect the pipeline and appurtenances at his own cost for sampling and testing for subsequent retests until coliform free samples are obtained.

27.3.15 CLEAN - UP

Upon completion of the installation of the water supply lines, distribution system and appurtenances, all debris and surplus materials resulting from the work will be removed and disposed off in a manner satisfactory to the Engineer-in-Charge.

27.3.16 INDICATION PLATES

The indication plates shall be installed in accordance with the drawings and as directed by the Engineer-in-Charge.

27.3.17 WASHOUTS

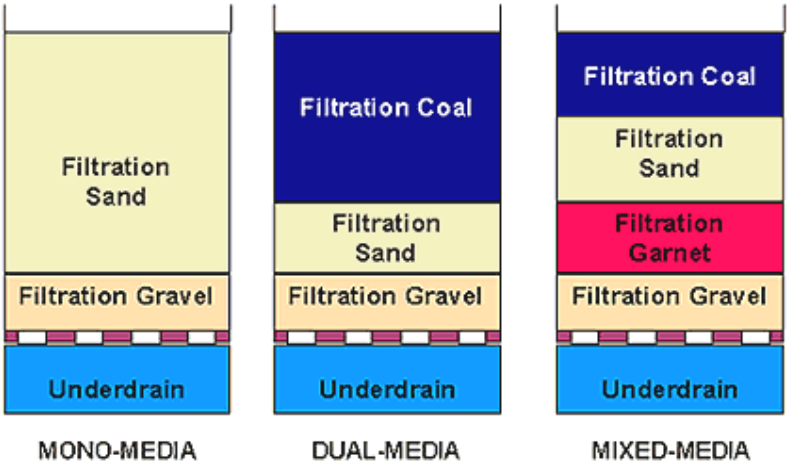
The design and locations of washouts shall be illustrated on the Drawings to be approved by the Engineer-in-Charge. Exact positioning shall be determined with regard to topography and to the approval of the Engineer-in-Charge. At least 10 ft. of the washout pipe-work, inclusive of the isolating valve, measured from the centre line of the pipeline, shall be laid at the same time as the pipeline and suitably capped to prevent ingress of foreign material. The minimum gradient for the washout pipe-work shall be 1 in 100.

27.4 WATER FILTRATION

27.4.1 FILTER MEDIA

The Contractor shall provide and place in the filters the filter media in accordance with the drawings and as directed by the Engineer. It is pertinent to note that at least five times quantity of sand shall be required to reproduce the specified quality of sand. The common source of sand in Pakistan is Haro river. The Contractor shall have to provide 10% excess filter media to replace the material loss during filter washing.

27.4.2 TYPICAL FILTRATION BED PROFILES



Table

Typical Media Design Values for various Filters

Parameter	MONO - MEDIA FILTERS	DUAL - MEDIA FILTERS	MIXED – MEDIA FILTERS
ANTHRACITE LAYER			
Effective size, (mm)	0.50 – 1.5	. 0.70 – 2.0	1.0 – 2.0
Uniformity Coefficient	1.20 – 1.7	. 1.30 – 1.8	1.4 – 1.8
Depth, (cm)	50 – 150	. 30 – 60	50 – 130
SAND LAYER			
Effective size, (mm)	0.45 – 1.0	. 0.45 – 0.6	0.40 – 0.80
Uniformity Coefficient	1.20 – 1.7	. 1.20 – 1.7	1.20 – 1.7
Depth, (cm)	50 – 150	. 20 – 40	20 – 40
GARNET LAYER	.	.	
Effective size, (mm)	.	.	0.20 – 0.80
Uniformity Coefficient	.	.	1.50 – 1.8
Depth, (cm)	.	.	5 – 15

27.5 HIGH DENSITY POLYETHYLENE (HDPE) / POLYETHYLENE (PE) PIPES AND FITTINGS

27.5.1 SCOPE

The work under this section of the specifications includes furnishing all plant, labour, equipment, appliances, materials and in performing all operations required in connection with providing and laying of High-density polyethylene (HDPE) or polyethylene Pipes and Pipe fittings, in accordance with the Contract or as directed by the Engineer and the manufacturer's recommendations.

27.5.1 MATERIALS

27.5.1.1 GENERAL

Materials shall conform to the latest referenced specifications and / or other provisions specified herein. Materials shall be new and unused. In cases where manufacturer are specified, materials shall be of the same manufacturers. In all other cases, the Contractor shall submit the names of the manufacturer from whom he intends to buy. Other information such as diagrams, drawings and descriptive data shall be supplied as desired by the Engineer. Approval of materials under this provision shall not be construed as authorising any deviations from specifications.

27.5.1.2 MANUFACTURING

The material from which the pipe is produced shall consist substantially of polyethylene, to which may be added only those additives that are needed to facilitate the manufacture of the polymer, and production of sound, durable pipe of good surface finish, mechanical strength. None of these additives shall be used separately or together in quantities sufficient to constitute a toxic hazard, or

to impair the fabrication of welding properties of the pipe, or to impair its chemical and physical properties.

27.5.1.3 PIPE

Pipes shall conform to International Standards Organisation (ISO) recommendations, I.S.O-4427: and shall be of specified class (SDR 11) capable of withstanding the specified working pressure and test pressure, suitable for jointing with solvent welded joints for small dia. pipes. Fittings shall be conform to ISO BS5114

27.5.1.4 QUALITY

The pipe shall not have any deter mental effect on composition of the water flowing through them. The quantities of any toxic substances extracted from the internal wall, of the pipes shall not exceed the values specified in ISO 4427:1966(E)

27.5.1.5 FITTINGS

Compatible fittings and specials for use with High-density polyethylene (HDPE)/ polyethylene (PE) Pressure Pipes shall be of the appropriate class and shall conform to International Standard / National standard. Fittings and specials shall have the required shapes, and dimensions of turned ends to fit the polyethylene pressure pipes.

27.5.2 HANDLING AND STORAGE

27.5.1.6 GENERAL

The Contractor shall be responsible for proper handling, as per manufacturers recommendations, of pipes and pipe fittings etc. All the material shall be stacked inaccordance with the manufacturer's recommendations at approved places as directed by the Engineer.

27.5.1.7 TRANSPORT

Transportation of pipes shall be done in such a way that they are secure and that no more than an absolute minimum of movement can take place on the vehicle during transit. The same care is needed if pipes are to be transferred from one vehicle to another, how short the final journey may be.

27.5.1.8 OFF-LOADING

Cranes shall be used for off-loading. Whole sequence of operations shall be carried out smoothly and without snatch. Rope or nylon slings, lifting beams with flattened hooks or scissor-dog shall be used. Hooks and dogs shall be well padded to prevent the pipe being damaged and shall be fitted with locking device. Steadying ropes are essential.

27.5.1.9 STORAGE

Pipes, and fittings damaged during handling, transporting or lowering shall be rejected and replaced at the contractor's expense. storage hall be under shade so that all polyethylene pipes &fittings are not exposed to sunlight and extreme heat.

27.5.1.10 STRINGING AND INSPECTION

Stringing, consists of placing pipes on the ground in line ready for laying. Care is again needed to prevent damage during this operation.

The turned ends of all pipes shall be inspected to ensure that they are free from any local irregularities which could affect the water tightness of the joint. All pipe shall also be visually inspected for evidence of impact damage. When such damage is detected, a thorough examination of internal surface in region of the pipe ends shall be made for sign of hair cracks. Damaged pipes, joints, and fittings shall be rejected and replaced at the expense of the Contractor.

27.5.3 JOINTING

Jointing hall be made by butt fusion/socket fusion using plain/socket ended polyethylene fittings except for joining of valves and appurtenances.

27.5.4 LEAKAGE TEST

It shall be in accordance with the specification set forth under 27.3.10

27.6 MEASUREMENT AND PAYMENT

27.6.1 COMPOSITE RATE

The measurement and payment for the items of the work of Tube-well & Water Supply hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

27.6.2 LABOUR RATE

The measurement and payment for the items of the work of Tube-well & Water Supply hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

27.6.3 QUANTIFICATION

The unit of measurement shall be measured as mentioned below in accordance with corresponding CSR items.

1. For surface area items, the quantity of work shall be measured by surface area. The unit of measurement shall be Square meter or Square foot. Following item of CSR are measured according to this criteria;
   Item No.: 27-1 to 27-14