LUDHIANA SMART CITY LIMITED

Design, Build, Testing & Commissioning of the following Packages along with Five Years of Operation and Maintenance including Two Years of Defect Liability in the ABD Area of Ludhiana under Smart City Mission:

- **Water Distribution Network & 24 x 7 domestic water supply**
- **Sewerage Disposal System**
- **Storm Water Drainage Network**

Specific Procurement Notice – Request for Bids (RFB)

VOLUME II

SECTION VII- WORK'S REQUIREMENTS

WORK'S REQUIREMENTS

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7.1 DEFINITIONS

The words, terms and expressions beginning with capital letters and defined under this Section 7.1 including those in Section 8 - General Conditions of Contract and those in Section 9 – Particular Conditions of Contract shall, unless the context otherwise requires, have the meanings as described thereto / herein:

a) "Consumer Relation Management Centres" means the special centres, planned and established by the operator to provide commercial and public relations services to consumers;

b) "Consumer or Customer" means the registered user of the water supplied through the meter at the private tap;

c) "Contract Completion" means the date as mentioned in the Contract Completion Certificate issued by the Employer's Representative to the contractor on fulfilment of his obligations in respect of both the Design-Build and the Operation Service;

d) "Contract Date" means the date on which the contract is signed;

e) "Contractor" means the agency to design build the works;

f) "Contractor's Personnel" means personnel hired and deployed by the Contractor under provision of Works and Services ;

g) "CPHEEO" means the Central Public Health and Environmental Engineering Organization under the Ministry of Urban Development, Government of India;

h) "Critical Measurement Points" means the locations agreed for undertaking measurement for facilitating the monitoring of minimum Service levels stipulated in Clause of Performance Standards;

i) "Design Build Period" means the period commencing from contract commencement date to the issue of Commissioning Certificate;

j) "Development Period" has the same meaning as Design Build Period;

k) "Electricity Department" means the local service provider supplying electricity for facilitating Operation of the facilities;

l) OHSR means Over Head Service Reservoir;

m) "Existing Assets" means infrastructure components, plant, machinery, equipment and any other units existing at the site as on the Commencement Date in the ownership of the Owner of Assets;

n) "Government Agencies" means all those agencies comprising of local, state and central government authorities directly or indirectly connected to provision of water and waste water collection services to the consumers in Ludhiana;

o) "Mandatory Works" are listed in the Bill of Quantities and are required to be constructed, installed or erected and commissioned and/or rehabilitated in line with the provisions of this Contract;

p) ''MCL" means the Municipal Corporation, Ludhiana

q) "Minimum Service Levels" means the levels of service to be maintained in the operations, maintenance and management and service delivery to consumers, described in Clause of Performance Standards as per Section 9 of the Bid Document;

r) "Minor Maintenance" means routine preventive or corrective maintenance works such as minor repair, reconditioning, or replacement of spare parts to ensure serviceability of existing and new infrastructure assets procured and installed by the Contractor including, pipes, electrical equipment, flow meters, pressure monitoring equipment, and consumer meters, starter panel, electro-mechanical equipment etc.;

s) "Mobilization Period" means the period commencing from the Contract Commencement Date and extends up to limit defined further in this document;

t) "New Assets" means infrastructure components, plant, machinery, equipment and any other units procured, supplied, installed, erected and commissioned by the Contractor during the Implementation period other than those existing on the site as on the Commencement Date;

u) "NRW" means Non-Revenue Water;

v) "Operator" means the same as the "Contractor".

w) "Operator's Demand Points" means the points where water will be supplied to the Operator by the MCL;

x) "Operating Payments" means the eligible payments towards operation, maintenance, repairs and service;

y) "Physical Losses" is part of the UFW and represents the volume of water leaking from the system;

z) "Planned Maintenance" means activities required to undertake preventive maintenance of any or all assets existing or proposed to be installed under the Contract and /or those taken over for operations under this contract;

aa) "PMC" means the Project Management Consultants as appointed by the Employer;

bb) "Potable / Drinking Water Specification" means the water quality requirements of potable water to be supplied to the Operator as stipulated in IS 10500, Guidelines for Physical and Chemical Parameters and Table 2.3 Bacteriological Quality of Drinking Water, in the Manual on Water Supply and Treatment, CPHEEO, Government of India, Ministry of Urban Development, New Delhi, edition May 1999;

cc) "Preparatory Period" or "Service Improvement Plan Preparation Period" is the period commencing from the Contract Commencement Date up to the time as specified in this document during which time the Contractor will prepare the Service Improvement Plan (SIP);

dd) "Project" means provision of 24x7 Water Supply System, Rehabilitation of Sewerage and Storm water drainage system for ABD area in Ludhiana City;

ee) "Project Information Memorandum" or "PIM" shall mean the report prepared by the Employer detailing the Project as provided in Section under Supplementary Information;

ff) "Release Event" shall mean an event beyond the responsibility of the Contractor or an event of force majeure;

gg) "Scheduled Design Build Completion Date" or "SDBCD" shall mean the date by which the construction of all the Works as per the agreed Service Improvement Plan are to be completed and certified by the Employer's Representative;

hh) "Schedules or Schedule" means the schedules forming part of this contract, or any one of them, as the context requires;

ii) "Scope of Services" shall mean all those services to be provided by the Contractor in accordance to the obligations, activities, responsibilities and tasks in implementing the contract;

jj) "Service Area" means the ABD area where Operator or its successors is responsible for conveying water to Consumers and maintain sewerage and storm water drainage infrastructure;

kk) "Services" means all those activities as defined in the Scope of Services;

ll) "SIP" mean Service Improvement Plan proposed by the Contractor and approved by Employer's Representative;

mm) "Sub-Project means" either the Water Supply or Sewerage system or Storm water drainage system component of the Project;

nn) ''UGSR'' means Underground Service Reservoir

oo) "Water Distribution Network" is the network of pipelines downstream of the water storage capacities;

pp) "UFW" means Unaccounted for Water and is part of the NRW. It means that quantity of water, which does not reach the desired destination from its upstream point of original measurement. UFW comprises:

- Apparent losses such as illegal water connections and metering inaccuracies; and
- Real losses which are leakages in the transmission networks and / or process losses.

7.2 PROJECT BACKGROUND

Ludhiana is the largest city in the state of Punjab. The city is spread over an area of 159.37 sqkm. The city is located in district Ludhiana, which is the most centrally located district amongst the 20 districts of Punjab State. It falls within the Malwa region of the State of Punjab. Geographically the city lies at 30 56' North longitude and 75 52' East of Latitude.

The city is well connected by Road and Rail Network with the rest of the country. It is located on Amritsar-Delhi G.T. Road (NH-1) and Amritsar-Ambala railway line which are considered the back bone of the state. The city is located at a distance of about 100 kms. North-West of Chandigarh, “The Capital of Punjab”. River Satluj flows at a distance of about 8 kms. to the North of the city.

The city is divided into 75 nos. of wards. The population of Ludhiana city was 16,18,159 as per 2011 census.

Ludhiana is amongst top 20 cities selected under first round of smart city mission. The projects under the smart city mission shall be executed through an SPV viz. Ludhiana Smart City Limited (LSCL). The objective of Smart Cities Mission is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of ‘Smart’ Solutions

In line with the mission objective, LSCL intends to take-up the works of infrastructural improvement with respect to Water supply, Sewerage and Storm water drainage **within ABD area**, under Smart city mission.

As per the scope, the works under Water Supply Improvement will include:

- Intake works and Water Treatment Plant
- Transmission network from WTP to UGSRs i/c construction of UGSRs and Pump House
- New distribution network based on District metering area (DMA) basis;
- House service connections with AMR meters;
- Provision of 24-hour water supply; and

Works under Sewerage Improvement will include

a) Cleaning, CCTV inspection and asset mapping of existing Sewerage system

b) Rehabilitation of the existing sewerage network by replacing the damaged / hydraulically insufficient sections & Trenchless rehabilitation by providing standalone Structural lining for old Brick/RCC sewers; and

Works under Storm water drainage Improvement will include

a) Cleaning, CCTV inspection and asset mapping of existing Storm water drainage system

b) Provision of new Storm water drainage system in uncovered areas and integrating the same with existing system;

The objective of the project is to improve the economic development by providing the infrastructure and service in the water supply, sewerage and storm water drainage sector. The improvement of quality of life and thereby effective contribution of beneficiary people in the economic activity is expected. The project therefore focuses on service delivery along with the creation of quality assets and service delivery monitoring systems.

A WATER SUPPLY

a) Distribution network configuration on District metering area (DMA) basis for maintaining NRW within acceptable limits;

b) Provision of individual metered connections to citizens;

c) Provision of uninterrupted continuous water supply; and

d) Efficiency improvement in water supply.

B Sewerage

a) Efficiency improvement in Sewerage system ;

C Storm Water Drainage

a) Storm water drainage network covering entire ABD area

b) Efficiency improvement in Storm water drainage system ;

7.3 PROJECT OBJECTIVE

The objective of the project is to supply water at desired quality and quantity at consumers connections as well as to effectively collect and convey the sewage and storm water to the respective outfall through separate networks.

Bidder has to include in his offer the entire Scope of Services needed for achieving the objectives and the intentions of the project. Broadly the project will have following components:

- ✓ SIP Preparation (Survey, Investigation, Methodology for project execution, Project Works Design Submissions & Approval)
- ✓ Design Build Period (Construction and commissioning of the project components, including continual designs submissions & approval as per the project methodology approved during SIP preparation)
- ✓ Operating Period

7.4 PROJECT LOCATION

The project area (ABD area) in Ludhiana is spread over 790 acres and bounded by Sidhwan canal, Ferozpur Road and National college road. Figure below presents the location of ABD area within Ludhiana city

Fig 1 – Project (ABD) Area

7.5 EXISING WATER SUPPLY SITUATION

Water supply to ABD area is managed by Municipal Corporation, Ludhiana. The water supply system in ABD area is based on sub-surface water. Ground water is being extracted through Tube-wells scattered over the ABD area. There are 25 nos of Tube-wells under possession of MCL, which are being used to supply water within ABD area through direct pumping into the distribution system. The water supply system in intermittent with 10 hours supply (4 hours in morning, 2 hours in noon and 4 hours in evening) in a day. The distribution system is about 30-35 years old and mainly comprises of AC and CI pipes. AC pipes reportedly contribute to more than 70% of existing water supply network in ABD area in Ludhiana.

The existing water supply system is in precarious state suffering from high NRW, inequitable distribution of water, intermittent supply, unmetered connections and quality issues. Further, the sustainability of present sub-surface based water supply system is also an important factor especially in view of increased rate of water table depletion and associated environmental and ecological issues

In order to move to an ecologically sustainable and financially viable water supply system ensuring continuous potable water supply to consumers, there is an urgent need of complete refurbishment of the entire water supply system. Metering is one of the key factor to ensure that the envisage benefits are realized to full extent.

7.6 EXISING SEWERAGE SITUATION

The sewerage system within project area primarily comprises of lateral and Trunk network of Stoneware, RCC and Brick sewers. Length of sewer network within project area is estimated to be around 55 kms. Age

of sewer network is reportedly 25-35 years. The details regarding exact alignment, size, depth and condition of existing sewers are not available.

There are no Sewage pump stations and Sewage Treatment Plant in project area. The sewage of ABD area is taken to Balloke STP through a Trunk Network of 72” – 78” – 90” – 96” sizes.

In absence of a separate storm water drainage system, the storm water is discharged through the sewerage system resulting in overloading of sewers and eventually leading to overflow of sewage during rains. Besides this, certain sections of existing sewers are either frequently suffering from blockage reportedly due to inadequate design slopes or have frequent sanitary sewer overflow due to insufficient hydraulic capacity.

Considering the fact that existing sewerage system is almost nearing its design life (generally 30 years), considerable investment might be required in near future to maintain the desired service levels. Therefore, there is an urgent need to prepare an Asset Management Framework for existing sewerage system. One of the requirements is to carryout de-silting and CCTV inspection of entire sewerage network within ABD area to gather the actual condition of sewers. Ascertaining the present condition analysed with estimated future flows will help the utility (MCL) to proactively carryout the operation & maintenance and plan for future capital investments.

Details of existing sewer network in project area is presented in table below.

S No.	Size in (mm)	Material	Length in Meters
1.	200	SW	44,412
2.	250	SW	1692
3.	300	RCC	1216
4.	400	RCC	1064
5.	600	RCC	2735
6.	700	RCC	1647
7.	1950	Brick (Non-Pressure)	2123

7.7 EXISING STORM WATER DRAINAGE SITUATION

The existing Storm water Drainage system in project area mainly comprises of network of Trunk drains and very few branch/lateral network, covering few parts of the project area. Owing to topography, excess storm water flows under gravity and discharges to Buddha nala (Outfall). There is no intermediate detention / storage or storm water pumping station in the project area.

Total length of existing trunk Storm water Drainage network is approx. 5.6 km with size ranging from 250 mm to 2850 mm. The material of construction is stoneware, RCC and Brick. In general, most of the drains upto 250 mm diameter are of stoneware. The Trunk drains above 700 mm are mostly constructed of cast in-situ Brick or combination of Brick and RCC. The drains are mostly circular in shape. The age of drainage system ranges from 30 - 35 years.

Since there is partial coverage of storm drainage system, the storm water finds its way through sewers. In view of the limited carrying capacity of sewerage system, the excess storm water flows on roads resulting in inundation. Moreover, overflow of sewage mixed with water creates unhygienic conditions leading to inconvenience to public.

A well planned storm water drainage system covering the entire project area is required to overcome the issues of overflow and inundation during rains.

Details of existing sewer network in project area is presented in table below

S No.	Size in (mm)	Material (Tentative)	Length in Meters
1.	400	SW	745
2.	900	RCC	99
3.	1600	Brick (Non-Pressure)	1294
4.	2550	Brick (Non-Pressure)	1350
5.	2850	Brick (Non-Pressure)	2100

7.8 SCOPE OF WORK

The Scope of contract for construction (Design Build) and Operating period is detailed out in sections below.

A) SCOPE OF CONTRACT FOR DESIGN BUILD PERIOD

The Scope of work for Water supply, Sewerage & Storm water drainage during Construction (Design Build) period is detailed out inTable-1 Table -2 & Table-3 respectively.

Table 1: Scope of work and services – Water Supply

S.N.	Components	Indicative Quantities
1	Preparation of System improvement Plan (SIP) within specified period and according to the contract conditions. SIP Preparation & Implementation shall include but not limited to the All Survey & investigations, water quality testing for ground and canal water, consumer survey, GIS Mapping by linking with geospatial data base, freezing DMA boundaries, Hydraulic Modelling, Control philosophy complete	For project area of 790 Acres (approx.)
2	Design, Supply and Installation of SCADA system required for effective management of the water supply system based on the continuous data, its analysis and management.	Entire water supply including Intake works, Raw water pump station, WTP, CWR, & Clear water pump station and UGSRs & Pump stations and Distribution system based on DMA requirements
	Intake works & Raw Water Components	
3	Design, Construction Testing & commissioning of intake structure of the required size at the canal tapping point, raw water gravity main of requires size from intake structure to Raw water sump, in	12 MLD capacity

S.N.	Components	Indicative Quantities
	conformity to the technical specifications and condition of bidding documents	
4	Design, Construction Testing & commissioning of RCC raw water sump and pump house with suitable foundation system, including all necessary inlet/overflow/draining etc piping arrangements with control valves, rungs, electrically operated control valves amenable to SCADA operation, all instrumentation including but not limited to flow meter, turbidity analyzer, water level indicator etc., and raw water pumping machinery of required numbers and configuration including all necessary mechanical, electrical & instrumentation and other installation works, providing all necessary suction/delivery piping arrangements with control valves and specials, arrangement for priming of pumps with suitable stand-by provisions all complete	1 Job
	Water Treatment Plant	
5	Design, Construction, trial run and successful commissioning of Complete Water Treatment Plant of output capacity of 10 MLD with suitable design in conformity of specifications provided in bidding documents and relevant BIS code of practices, having provision of coagulation & flocculation, sedimentation, Rapid gravity filtration, disinfection, clear water reservoir and pump house, recycling of filter backwash & clarifier sludge, dewatering and disposal of sludge, laboratory, Administration building, Chemical house, chlorination system, Master control room, all interconnecting piping & by-pass arrangement including all necessary Mechanical, Electrical, Instrumentation and SCADA works suitable for automated operation of plant alongwith all internal & external electrification works including control panels, DG, for all the plant units and ancillary buildings	New Water Treatment Plant of 10 MLD output capacity New Clear Water Pump Station with Minimum 3 nos (2 Working + 1 Standby) Clear Water Pumps including water hammer/Surge protection devices New Clear Water Reservoir with minimum 1670 m^3 capacity Providing Master Control Centre for Water Distribution Monitoring and Control including Office cum SCADA Room. Provision of space for later extension to 12 mld capacity for WTP along with layout of WTP and other structures
	Water Transmission Pipes	

S.N.	Components	Indicative Quantities
6	Design, Supplying, laying, jointing, testing & commissioning of DI (K7) clear water transmission mains of required size and length, from Clear water pump station at WTP to proposed Underground service reservoirs including all necessary earthwork, valves & specials, flow & pressure measurement and control devices/instruments, valve chamber, supporting structures, anchor/thrust blocks, road restoration etc.	As per design requirement and scope of work 4.1 Kms (250 mm to 400 mm)
	Underground Service Reservoirs & Water Distribution Pumping Stations	
7	Design, Construction, Testing & commissioning of RCC underground service reservoir sump and pump house with suitable foundation system, including all necessary inlet/overflow/draining etc piping arrangements with control valves, water hammer / surge protection devices, rungs, vent pipes, manhole chamber cover & frame, electrically operated control valves amenable to SCADA operation, all instrumentation including but not limited to flow meter, turbidity analyzer, residual chorine analyzer, pH analyzer, water level indicator etc., and clear water pumping machinery of required numbers and configuration to ensure 24x7 water supply, with variable frequency drive including all necessary mechanical, electrical & instrumentation and other installation works, providing all necessary suction/delivery piping arrangements with control valves and specials, arrangement for priming of pumps with suitable stand-by provisions all complete Location – one each at At Leisure Valley Park and Rose Garden	Two Nos- One for each zone Capacity and pump configuration as per design requirement and scope of work
	Water Distribution System	
8	Design, Supplying, laying, jointing, testing & commissioning of clear water Distribution mains of required size and length, from Underground	As per design requirement and scope of work. HDPE (PE 100/PN6) and DI K7

S.N.	Components	Indicative Quantities
	service reservoirs to Consumers including all necessary earthwork, valves & specials, flow & pressure measurement and control devices/instruments, valve chamber, supporting structures, anchor/thrust blocks, road restoration etc	distribution pipes with diameter ranging from 110mm to 400mm - 85 Kms
9	Refurbishment of Tube-wells by providing and/or replacing/rehabilitating the civil, mechanical, electrical facilties at existing Tube-well locations including all necessary piping, valves, valve chambers, instrumentation & automation all complete	7 Nos
10	Design, Supplying, laying, jointing, testing & commissioning of transmission mains (DI – K7) of required size and length from Tube-wells to respective Underground service reservoirs including all necessary earthwork, valves & specials, flow & pressure measurement and control devices/instruments, valve chamber, supporting structures, anchor/thrust blocks, road restoration etc	As per design requirement and scope of work. 4.1 Kms (200 mm to 350 mm)
11	Electromagnetic bulk flow meters, ultrasonic digital level transmitter, level transmitter, level controller, online water quality sensors LED display, data logger, GSM Modem with connectivity and software for PC through SCADA.	As per design requirement and scope of work
12	Metered House Service Connection, with Electro fusion saddle, Ferrule, HDPE fittings and MDPE pipe, ball valve, AMR type consumer meter, meter box where required etc.	Approx. 5,000
13	Operation and maintenance of entire system including water distribution service delivery with performance guarantee, meter reading, billing system and customer services including customer service centres.	5 Years of O&M including 2 years of DLP after commissioning

Table 2: Scope of work and services – Sewerage

S.N.	Components	Indicative Quantities
1	Preparation of System improvement Plan SIP within specified period and according to the contract conditions. SIP Preparation & Implementation shall include but not limited to the Topographical survey to determine sewer alignment, levels, M/H positions, including tracing of buried manhole chambers along alignment, measurement of exact length between manhole chambers & invert level ; Temporary/ permanent plugging and blocking of sewer line, branch connections for diversion of flows and removal of all plugs etc; Provide everything else required for diversion of flow by pumping and/or bypassing and to maintain the sewerage system functioning normal and managing the flow without any surcharging, overflows etc. during the de-silting, cleaning of the sewer including loosening, desilt and thoroughly cleaning and removing debris and objects such as boulders, bricks etc. bacteriological slimes, roots, encrustations, grease, carbonated deposits, etc. from the sewer line including disposal of silt / debris/ malba / objects etc. including solidification of silt/ malba /debris for disposal to the dumping sites, CCTV/ Photographic survey including pan and zoom inspection of laterals and defects and submission of reports, Hydraulic modelling complete	For project area of 790 Acres (approx.)
2	Design, Supplying, laying, jointing, testing & commissioning of uPVC (SN 8 class) and RCC (NP 3 with PE lining) pipes of required size and length, including all necessary earthwork, manhole chamber & Inspection chambers, road restoration etc	2.7 Km
3	Design, manufacture, supply, deliver on site and install Standalone structural lining system including preparatory site work and construction of working shaft and reinstatement and making good of rehabilitated sewer and lateral connections etc. and end grouting/sealing of the migration gap between the liner and the sewer at manhole chambers including rehabilitation of Manhole chambers / Chambers including sealing of leaks, installation of PVC encapsulated footsteps, plastering, grouting and epoxy coating to lower portion of the manhole chambers up to 1m height above the benching and epoxy painting on cement plastered surface up to top of the manhole chambers, haunch repairs of manhole chambers/ chambers as specified and raising of manhole chambers and installation of new SFRC frame & covers	3.2 Km

S.N.	Components	Indicative Quantities
	to required level; Post CCTV video survey/Photographic survey of the rehabilitated sewer and submit video/photographic reports of size 600 mm, 700 mm and 1950 mm	
4	Operating and Maintenance of Sewerage System	5 Years of O&M including 2 years of DLP after commissioning

Table 3: Scope of work and services – Storm water drainage

S.N.	Components	Indicative Quantities
1	Preparation of System improvement Plan (SIP) within specified period and according to the contract conditions. SIP Preparation & Implementation shall include but not limited to the Topographical survey to determine existing storm water drains alignment, levels, M/H positions, including tracing of buried manhole chambers along alignment, measurement of exact length between manhole chambers & invert level; Hydraulic modelling all complete	For project area of 790 Acres (approx.)
2	Desilting & condition assessment of the existing storm water drainage system by Temporary/ permanent plugging and blocking of storm line, branch connections for diversion of flows and removal of all plugs etc; Provide everything else required for diversion of flow by pumping and/or bypassing and to maintain the storm water drainage system functioning normal and managing the flow without any surcharging, overflows etc. during the de-silting, cleaning of the storm water drain including loosening, desilt and thoroughly cleaning and removing debris and objects such as boulders, bricks etc. bacteriological slimes, roots, encrustations, grease, carbonated deposits, etc. from the drains including disposal of silt / debris/ malba / objects etc. including solidification of silt/ malba /debris for disposal to the dumping sites, CCTV/ Photographic survey including pan and zoom inspection of laterals and defects and submission of reports,	5.6 Km.
3	Design, Supplying, laying, jointing, testing & commissioning of RCC (NP 2) pipes of required size and length, including all necessary earthwork, manhole chamber & Inspection chambers, road restoration etc.	29.5 Km

S.N.	Components	Indicative Quantities
4	Operation and maintenance of system.	5 Years of O&M including 2 years of DLP after commissioning

The Scope of Services shall include all technical, managerial, administrative, commercial, environmental, and social interventions as required in accordance with acceptable, prudent water, waste water & storm water drainage utility construction and management practices, ensuring safe and sustainable drinking water supply services and efficient sewage and storm water drainage collection & disposal facilities for the Consumers in the Service Area. The Scope of Services mentioned in Tables above is neither exhaustive nor complete and is indicative only and the contractor is required to undertake his own detailed investigation of the Project Facilities to determine the complete Scope of Services for achieving the Minimum Service Levels as stipulated in the bid document.

B) SCOPE OF OPERATION PHASE AND MAINTENANCE

The Operation Services are divided in 2 categories.

1) O&M of created assets during DB period.
2) O&M of existing Assets as indicated in this documents.

The Contractor will be required to operate and maintain the constructed and existing assets in such way to meet the consumer demands and as agreed upon during the SIP stage.

Table 4: Scope of Works under Operation Phase

S No	Operational Requirements	
1	Establishment of Consumer Relation Management Centres (1 No.) and central control centre at proposed WTP location including furniture, manpower, computer software and hardware as per requirement.	1 No.
2	Operation and Maintenance of entire water supply system in service area including Water Treatment Plant, Raw water and clear water transmission system, water distribution service delivery with performance guarantee, meter reading, billing and customer services from CWR's to the UGSR's and entire distribution system in an uninterrupted manner.	
3	Management & maintenance of the sewerage network for collection & conveyance of sewage including maintenance of entire system from property chambers upto outfall to trunk sewers outside service area	

S No	Operational Requirements	
4	Management & maintenance of the storm water drainage network for collection & conveyance of storm water including maintenance of entire system from gully chamber upto outfall location	
5	Contractor will provide continuous on-the-job training that will start from the day the contractor gets mobilized, and other capacity building programs by the contractor as important regular activities so that there is a smooth takeover from contractor on contract completion from commissioning date	

The Scope of Services shall include all technical, managerial, administrative, commercial, environmental, and social interventions as required in accordance with acceptable, prudent water, waste water & storm water drainage utility construction and management practices, ensuring safe and sustainable drinking water supply services and efficient sewage and storm water drainage collection & disposal facilities for the Consumers in the Service Area. The Scope of Services mentioned in Tables above is neither exhaustive nor complete and is indicative only and the contractor is required to undertake his own detailed investigation of the Project Facilities to determine the complete Scope of Services for achieving the Minimum Service Levels as stipulated in the bid document.

7.9 SUMMARY OF OBLIGATIONS UNDER THE CONTRACT

The summary of obligations related to Water supply, Sewerage and Storm water drainage works under the Contract are mentioned in the **Table 5**, **6** and **7** respectively.

Table 5: Water supply

Sl. No.	Description	New/Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
1.	New Intake works, Raw water main and Raw water pumping station	New	Yes	No	Yes	Yes	Yes
2.	New Water Treatment Plant	New	Yes	No	Yes	Yes	Yes
3.	New Underground Service Reservoirs and Pumping station at Leisure valley park & Rose Garden	New	Yes	No	Yes	Yes	Yes
4.	New Treated water	New	Yes	No	Yes	Yes	Yes

Sl. No.	Description	New/Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
	transmission pipeline with sizes ranging from 250 mm to 400 mm						
5.	Laying 85 km of new water supply Distribution system	New	Yes	No	Yes	Yes	Yes
6.	Approx. 5000 new House Service Connections with AMR meters for the new supply system,	New	Yes	No	Yes	Yes	Yes
7.	New Service centres for O&M.	New	Yes	No	Yes	Yes	Yes

Table 6: Sewerage

Sl. No.	Description	New/Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
1.	Cleaning, CCTV inspection of existing Storm water drainage network	Rehab	Yes	Yes	Yes	Yes	Yes
2.	Supply, Laying, Testing and Commissioning of Sewerage Collection network of uPVC and RCC-NP3 (with PE lining) pipes with Manhole chambers, Ventilating Shafts and other allied works etc. complete	New	Yes	No	Yes	Yes	Yes
3.	Trenchless Rehabilitation of existing 1950 mm Brick sewer by Standalone Structural lining	Rehab	Yes	Yes	Yes	Yes	Yes
4.	Operating and Maintenance of entire Sewerage System within service area	New	Yes	No	Yes	Yes	Yes

Table 7: Storm Water Drainage

Sl. No.	Description	New/Rehab.	Scope				
			Design	Rehab	Build	Operate	Maintain
1.	Supply, Laying, Testing and Commissioning of new Storm water drainage network of RCC-NP2 pipes with Manhole chambers and other allied works etc. complete	New	Yes	No	Yes	Yes	Yes
2.	Cleaning, CCTV inspection of existing Storm water drainage network	Rehab	Yes	Yes	Yes	Yes	Yes
3.	Operating and Maintenance of entire Storm water drainage System within service area including gully chamber and upto discharge location	New	Yes	No	Yes	Yes	Yes

Important milestone and key time periods as per the terms of Contract are given in Table 8

Table 8: Milestone and Key Time Periods

S. No.	Sectional Milestone	Completion Time from stipulated date of contract start (days)	Event of start	Activities
Design Build Period				
1	Mobilisation	30 days	Commencement Date	
2	Preparatory period - Preparation and approval of Service Improvement Plan (SIP); Preparation of Plans & Design	90 days	Commencement Date	
3	SIP Implementation	640 days	Commencement Date	Design, Construction, testing, commissioning and completion of all works as per milestones

S. No.	Sectional Milestone	Completion Time from stipulated date of contract start (days)	Event of start	Activities
				to deliver water, sewerage & Storm water drainage services
Operation Service delivery				
4	Operation and Maintenance of entire existing and new assets in service area as per scope of work	1825 days	From date of takeover	O&M of entire water supply, sewerage and storm water drainage assets
5	Handing over back to Employer	30 days	30 days before End of O&M period	Joint verification of assets, Issuance of O&M period completion certificate and joint signing of Handing Over document

Note: To the extent possible, water supply pipeline and distribution system, sewerage network & Storm water drainage network on a particular road will be laid simultaneously.

7.10 PHASING OF CONTRACT

The Contract is divided into two stages (i. design & build ii. Operation and maintenance services) spread over the contract period; from the stipulated date of Contract Commencement up to the Contract Completion Date.

I. Mobilization, preparatory and construction period as per approved designs and

II. Operation, Maintenance, Manage, Repairs and Service Delivery Period during the contract period till contract completion date.

7.10.1 Mobilization Period

During the 30 days mobilization period the contractor is required to:

- Establish a furnished project office in Ludhiana.
- Employ/mobilize the staff required for starting the preparatory work
- Mobilize the teams for Survey & Investigation
- Procure GIS based maps, project management etc.
- Collect and study existing utility networks and facilities
- Baseline study for consumers water consumption pattern, DMAs

- Mobilize vehicles, office (furnished), equipment, communication equipment.

7.10.2 Preparatory Period (Preparation of design during preparatory period)

During the Preparatory Period, the Contractor is required to:

- Familiarize himself with the project site condition after required consultation
- Collect data and maps etc. and review designs of project components etc.
- Confirm/ conduct topographic survey to ascertain the levels, road width, existing services etc.
- Surveys for all underground utilities up to 3.0 m depth and marking on GIS based maps by linking with geo referenced points.
- Carryout desilting and CCTV inspection of entire existing sewerage and storm water drainage network
- Conduct Door to Door consumer survey and prepare data base of the existing properties with service connection details
- Prepare an asset inventory report for existing infrastructure within service area.
- Prepare & submit detailed design and drawings of entire Water supply scheme including all the components from Intake works upto distribution system including consumer meters including Civil, structural, Electro-mechanical, Instrumentation, SCADA works
- Prepare & submit system improvement plan alongwith detailed design of Sewerage and Storm water drainage system including hydraulic modelling

7.10.2.1 Deliverable Documents for SIP

(i) Design should be prepared including sectional completion requirements;

(ii) Detailed design, drawings and cost estimates of works;

(iii) Work plan, Methodology and timelines for implementation should be in line with the Employer's requirements;

(iv) Detailing of integrated Contract Management Information System by using latest software like Primavera, Microsoft office architecture, data capture, management and reporting structures, protocols including all related hardware, software, installation; .

(v) Contractor Personnel Deployment Plan;

(vi) Construction Plant and equipment deployment plan;

(vii) Cash-flow for the entire contract with sectional completion break up;

(viii) Asset Replacement Schedule with justification;

(ix) Detailed methodology for continuous monitoring of the performance of the Contractor in achieving and maintaining the Performance Standards for release of the eligible Operating Payments;

(x) Compliance matrix of contract and service requirement, O&M requirement and other requirement like social, environmental, resettlement etc and;

7.10.3 Operating and Management related Deliverable

(i) Annual Operating Plan (AOP) covering all operations, maintenance and management requirements in the Service Area;

(ii) Emergency Response Plan (ERP); this shall also separately include response plan for effective emergency rectifications against any major break downs occurring from the WTP up to the service area of this contract;

(iii) Public Relations Plan;

(iv) Standard Operating Procedures (SOPs) for routine operations and emergency responses;

(v) Water Quality Monitoring Program;

(vi) Energy optimization program;

(vii) Transmission System extension/ expansion policy;

(viii) Detailing of an Integrated Management Information System (MIS) including its architecture, data capture, management and reporting structures, protocols including all related hardware, software, installation, and operation and maintenance requirements; and

(ix) Periodic reporting plan including the formats for different performance reports;

(x) The computer hardware and software improvement plan for continued operation of the MIS, instrumentation and SCADA

7.10.4 SIP Schedule

Schedule of various activities of the design is shown in Table 9:

Table 9: SIP Schedule and Penalties

S N	Activity	Target period for completion from contract commencement date	Amount of penalty to be recovered in case of delayed output
1	**2**	**3**	**4**
1	Mobilisation on site	30 days	
2	Topographical survey and ground profiling of the service area, plot surveys and any other surveys to ensure accurate design.	45 days	Rs. 25,000 per day
3	Geotechnical Investigations at plots where components of water systems will be constructed and along alignments where pipelines will be laid	45 days	Rs. 25,000/- per day

S N	Activity	Target period for completion from contract commencement date	Amount of penalty to be recovered in case of delayed output
1	**2**	**3**	**4**
4	Desilting and CCTV inspection and submission of reports alongwith for existing sewerage and storm water drainage infrastructure	75 days	Rs. 25,000/- per day
5	Development of complete GIS map using Arc GIS/ for the water supply, sewerage and storm water drainage system	90 days	Rs. 50,000 per day
6	Complete system design and drawings, preparation of abstract of final quantities and cost estimates for the designs	90 days	Rs. 75,000 per day
7	Preparing PERT chart, manpower, equipment, mobilisation plan, cash flow plan, detailed methodology of continuous monitoring etc.	90 days	-
8	Detailed O&M plan, Standard Operating Procedures and policies plan, Performance measurement plan.	90 days	Rs. 75,000 per day
9	Compilation and submission of designs and drawings in complete	90 days	Rs. 75,000 per day

The Contractor shall submit the outcome of each activity for review of Employer's Representative immediately after completion of the activity. Employer's Representative will review the outcomes on regular basis and will submit their review comments within 21 days of receipt of the document.

Contractor will develop data bases for water supply hydraulic and water quality parameters and the daily Bulk Supply at each delivery point including hourly flows and total supply, raw water received by the contractor and treated water produced at water treatment plant, quality of water produced, pump operations, electric parameters and unaccounted for water (UFW).

Contractor shall also submit the activity wise the Monthly Report for monitoring by the employer. Progress of all activities will be reviewed on weekly basis for design part. Reports will be on Monthly basis during construction part and daily basis during operations part.

In case of delays in meeting timelines of design activities, penalty as per the sums indicated in column 4 will be imposed and recovered from due payments. If the delays that occurred in activity milestones are covered by the Contractor within the stipulated or extended period for Compilation and submission of designs in complete, which is not attributable to Contractor, penalty imposed on account of such delays will be refunded.

7.11 Methodology of Services

7.11.1 Distribution Network Improvement (DNI) on DMA basis

The Distribution Network Improvement (DNI) shall be based on DMA basis. The Contractor shall, set up hydraulically isolated District Metered Areas (DMAs) within the service area of each UGSR. Each DMA comprising of about 1000 to 2000 consumer connections shall be considered as basic administrative unit for the purpose of sectional commissioning and O & M purpose. The Contractor shall design water supply distribution network on DMA basis to ensure equitable, continuous, pressurized water supply to the Consumers by using the hydraulic model and simulating both present (2018) and future (Year 2048) conditions, Each DMA preferably have one inflow point and be isolated by installing valves / end plugs. DMA at entry point will be provided with a bulk flow meter and water quality sensor, pressure transmitter. Each DMA will have at least two Critical Measurement Points (CMPs) for continuous logging of pressure, and the CMPs shall be such that they should be at the critical low pressure areas (highest and/or farthest points from the command reservoir). The performance parameters of the contractor including O& M period shall be assessed on DMA basis. The O&M agencies (EMPLOYER) will also organize themselves in the same manner over the contract period. DMA wise monthly reports will be generated to assess the DMA performance. Monthly meter readings will be taken and will be linked to the NRW assessment system. Contractor also may suggest good management practices. Lessons learnt from other utilities/agencies will also be incorporated for better management services

7.11.2 Methodology for designing of DNI

The existing distribution system will not be used in the proposed Distribution Network Improvement (DNI) plan, as the entire existing distribution network will be replaced with new one under this contract. Since entire distribution system shall be new; therefore no measurement of current NRW level is required. Scope of contractor will involve both technical and consumer orientation with social approach. The consumers shall be taken in confidence and be informed time to time for the status update. A disconnection of old connections and old pipelines is very critical. Contractor will disconnect old connections and pipelines on commissioning of new pipelines. It will be verified by project consultant before making payment in DMA. All the connections shifted from old to new system and new connections given shall be recorded on GIS based database duly attaching each connection with meter serial number to respective property with social and contact data of each consumer available in database. This database shall be of use to understand demand of water and also for servicing consumers. Contractor will proactively provide individual house connections to poor households including those in slums and informal settlements.

Works shall be planned and executed to provide continuous pressurised water supply in each DMA. The Zones/DMAs shall be equipped with the instrumentation for monitoring the performance of service delivery in the area. The instrumentation capable of transferring the real time data to the SCADA system shall include the parameters of performance evaluation of the contractor during the operation, maintenance and service delivery. It shall include the DMA inlet flow meter, DMA outlet flow meter if any (if the outlet of one DMA forms the inlet for other), flow and pressure control valves, level transmitters at reservoirs, the

pressure transducers at critical measurement points. The consumer meter reading data for a given month of all the consumers within DMA shall be entered in the computer every month and shall be used in conjunction with the Zone/DMA inlet and outlet meter data for the month to work out the NRW of the Zone/DMA/complete system. The pressure readings transmitted by the pressure transducers at critical points in DMA shall not only be used for the performance monitoring and payment mechanism but also for continuously improving the model, using it for providing connections to the new consumers duly understanding its effect on the system' interpreting the possible leakages in the DMA using the bulk flow meter and consumer meter data and running the model to understand the implication of the pressure readings.

The Contractor's approach and methodology towards this work shall be in line with the overall principles and thinking of the Employer stated above. The SIP for DNI shall be compatible with these concepts.

7.11.3 Methodology for measurement of NRW and real losses during operation services

The contractor's methodology shall also spell out how the NRW and real losses will be measured within his battery limit which starts at the outlet of the WTP's and ends at the consumers within service area.

The monitoring is to be started as soon as DMA is commissioned and the contractor will submit details in key parameters (pressure, bulk supply, consumer readings zone/ DMA wise etc.). The complete water supply system will be controlled and operated on SCADA. The bulk supply of water at each stage i.e. CWR, UGSR, Zone & DMA will be accessed through SCADA on specifically designed software. Bulk flow meter readings should register every day at fixed time. It should be accomplished through SCADA report generation. Domestic water meter reading at stipulated time in stipulated periodicity (the periodicity can be kept weekly or as felt fit by the Engineer). The format output for the monitoring should be evolving in such manner which shall clearly shows key parameters of water supply system specifically NRW evaluation calculations. As per the assessment of NRW, other interventions required to control leakages/losses should also be identified which will have to be taken up to accomplish desired performance parameters specified under the contract.

On the sewerage front, the contractor shall prepare detailed asset inventory of existing sewerage infrastructure through survey & investigations including CCTV survey to ascertain the alignment, size, depth and condition of sewers. Based on the data, hydraulic modelling shall be carried out to check available capacities of different sections vis-à-vis estimated flows for present (2018) and future (2033 & 2048) conditions. The contractor shall develop the SIP with overall goal to connect each and every property in service area to the system and to transport the collected sewage and sullage within service area to the outfall sewer/s. The contactor's SIP when functional shall continue to provide service as per the performance standards mentioned for service to the consumers. The methodology shall be prepared and got approved from the Employer before preparing detailed SIP.

The contractor shall also prepare detailed asset inventory of existing storm water drainage infrastructure through survey & investigations including CCTV survey to ascertain the alignment, size, depth and condition of drains. The SIP shall be developed considering integration of the proposed new network of drains with existing system.

7.12 Methodology for commissioning of zone cum DMA

The contractor shall give a complete methodology for commissioning of DMAs which shall include an exhaustive and sequential method with the formats designed to achieve and monitor:

- The distribution system pipelines in a DMA/ zone hydraulically tested
- Readiness of database of all the properties and consumer registered / unregistered to be connected to the new system on GIS based map of the DMA with clear indication of roads.
- Proposal to connect all the consumers to the new system and methodology for pressure and flow control of each consumer vis-à-vis his registered demand.
- Public awareness programs planned to achieve people's participation in managing demand by using the continuously available water to their absolute need only and not to waste, and to communicate importance of metered system and its benefit.
- The water to be taken in UGSRs shall be calculated based on the demand of the population with ceiling of 150 lpcd in any case. In no case in order to sustain demand of one zone for continuous water supply, other area shall suffer. A continuous consumer awareness to spread the demand in different hours of the day to bring it to the use pattern considered in design shall be tried. The initial teething troubles shall be overcome at the earliest but not later than 45 days of commissioning of zone/DMA.
- The billing shall be on time without fail for which a detail program shall be prepared. The first bill on time gives early signal for those who have increased demand just because water is available continuously.
- A vigilant surveillance to see that no reverse flow occur, no high consumptions go unnoticed shall be done for first some months. The pattern of water flowing out of UGSRs be critically observed for the entire day at 10 minutes interval for initial months. Unusual night flows shall be checked by surveillance visits in the night at the time when unusual high flow is seen on bulk outlet meter.

7.13 Methodology for Measurement of Performance Standards

The Contractor shall develop a robust methodology and framework for measurement and monitoring of Performance Standards stipulated under the contract and proposed as part of the SIP. The Employer with the assistance of the Employer's representative shall verify the same and upon agreement between the Parties the agreed methodology shall form the basis for monitoring the performance of the Contractor and apply the Non Performance Adjustments on the eligible Operating Payments in case of failure to meet the performance standards.

7.14 Methodology for Site Acquaintance

As part of this activity, contractor is required to:

i. Establish contact with all relevant stakeholders MCL, PWD, NHAI, Electricity Distribution Company, Telecommunication companies and the local traffic police and other government agencies including consultants.

ii. Become familiar with the water supply system in service area, and the applicable standards and guidelines for water supply design, and with existing assets and current on-going works in the Service Area. The contractor shall also study the works being done by MCL and other departments being undertaken during the same period in the same area.

iii. Satisfy himself with the nature and scope of work and the prevailing Site conditions.

iv. Be familiar with governing Laws and regulations in order to undertake studies and construction activities under the Contract such as:

a. Occupational health and safety including workers compensation;

b. Signage for construction works and;

c. The permissions and co-ordination required from the different agencies

7.15 Survey and Mapping

The contractor shall digitize and validate all the footprints, roads, water bodies, electricity poles, water supply and other infrastructure components in the service area on a base map provided by the employer. A detailed topographical survey of the area shall be carried out using Total Station equipment and the spot levels and the contours at 0.5 m interval shall be drawn on the GIS based digitized map in Arc GIS. Contractor will survey all underground utilities upto 3.0 m depth and mark on GIS based maps by linking with geo referenced points.

7.16 SIP Implementation

The Scope of Services during the implementation Period shall essentially comprise of implementing the approved SIP based on the hydraulic model prepared for water distribution based on DMA approach, sewage network and storm water drainage network. SIP will be implemented in accordance to international best practice and industry standards and sufficient care shall be taken by the Contractor in minimizing supply interruptions, traffic disruptions and ensuring good and timely communications with the Consumers in the Service Area. During work execution, contractor would be required to inform the residents, say, of a particular street, well in advance about the type of work, inconvenience expected, timelines for various works, etc. Contractor has to have a strong Public Relations and Community Outreach team. Contractor will plan sequencing of activities to synchronize water pipeline works, sewer works & storm water drainage to minimize the road excavation and restoration in the streets which will have two or all three pipelines.

All the Works and interventions proposed as part of the SIP shall be in conformity with the Specifications set out in the Employer's Requirements. Implementation of the water supply transmission and distribution network, sewer collection networks and storm water drainage networks in a given street / road shall be taken up simultaneously so that the people living in the area are not affected multiple times.

7.16.1 Construction of New Intake works and Raw water pump house

The scope includes construction of intake works at Sidhwan canal, raw water sump and pump house. The raw water shall be pumped to inlet chamber of WTP by DI (K9) rising main of required diameter and length.

7.16.2 Construction of New WTP

Scope includes the construction of a new WTP of 10 MLD capacity including all civil, mechanical and Electrical, Instrumentation & SCADA items.

7.16.3 Construction of New Transmission Pipes

The scope includes Supply laying, jointing, testing and commissioning, and operation of the new transmission pipes.

7.16.4 Construction of new Water Distribution Pumping Stations

The scope includes the construction of 2 nos new underground service reservoir including pump house with required configuration of pumps to ensure 24x7 water supply with minimum 17 m pressure at consumer end

7.16.5 Distribution Network works

The contractor will implement the distribution network works in accordance to the technical specifications and prudent industry practices. The primary objective of the Distribution Network is to ensure rationalized, equitable, continuous and pressurized water services to the Consumers in the Service Area on a DMA based approach.

7.16.6 Consumer Connections

The Contractor shall undertake installation of new consumer connections using Electrofusion welded connection, a compression joint to receive HDPE pipe from tapping saddle followed by a compression elbow and then MDPE pipe till ball valve followed by installation of a Consumer meter, accessories and meter box (as required) at the nearest point inside the Consumer property boundary.

7.16.7 Consumer Water Meters

The consumer meters shall be AMR domestic water meters, inferential type, multi jet, magnetically coupled, having dry dial, Class 'B' conforming to IS-779 : 1994 with up to date amendments or ISO 4064:2014 standard and shall have ISI/EEC/OIML/MID certification mark on each meter and shall be with protection class of IP-68. Water meter shall have anti magnetic properties/Immunity, as specified ISO: 4064-2014.

The water meters shall be equipped with RF/GPS/GPRS based wireless remote trans-receivers inbuilt/directly fitted on the meter & wireless for A.M.R. reading. Remote Data collector / Concentrator with 2G/3G modem, aerial / panel antenna for outdoor installation, Repeaters (if required), with necessary Cabinet & Extra antenna wire shall be provided for Outdoor installation. Meter Reading Software for Hourly data collection shall be provided. The cost includes all license fee for the software upto the contract period.

7.16.8 District Meters for Metered Areas

District meters shall be Electromagnetic Meters (EM) either powered by electricity with adequate protection against power fluctuations or EM's for remote areas with adequate battery power supply. All EM's have to be connected to the SCADA System.

In the District Metered Areas, the water meter shall be adequately maintained. Pressure shall either be controlled by the topography or pressure reducing valves, if necessary.

7.16.9 Sewerage system

The Contractor shall rehabilitate the existing sewerage works in service area as detailed hereunder and included as per the Bill of Quantities (BOQ) for the purpose of pricing in the Price Bid.

i. Supply, laying, jointing, hydraulic testing and commissioning the sewer network along with manhole chambers and all allied works; as per scope indicated in the bid documents;
ii. Construction of property chamber and making connections between manhole chamber and property chamber (scope excludes internal piping works within property boundary upto property chamber).

iii. Rehabilitation of damaged trunk sewers by trenchless structural lining method, wherever replacement of existing sewer by open cut method is not feasible

7.16.10 Storm water drainage system

The Contractor shall augment and rehabilitate the existing storm water drainage system in service area as detailed hereunder and included as per the Bill of Quantities (BOQ) for the purpose of pricing in the Price Bid.

Supply, laying, jointing, hydraulic testing and commissioning the storm water drainage network along with manhole chambers and all allied works; as per scope indicated in the bid documents;

7.16.11 Road restoration

Road restoration is a critical activity which requires special attention of the contractor. Following guidelines should be followed:

a) The contractor shall have to restore the road up to WMM stage including refilling trench in layers, watering, rolling and compacting to within 10days after trenching is completed in a particular street/reach. The contractor shall ensure that uncovered WMM length in total does not exceed 5.0KM at any stage of work and will complete the bituminous work regularly.

b) Contractor shall erect informatory board at his own cost showing type of work, inconvenience expected & timeline for various construction activities going to take place in a particular street or a particular reach of road as per direction of Engineer in charge. Contractor shall submit detour and traffic control plan and get approval from Engineer and appropriate government authorities prior to carryout the works. All necessary provisions shall be ensured as defined in clause 7.39.8 of bid document.

c) Contractor shall deploy a community outreach team to make strong relation with public prior to start of work in a particular ward/ area.

d) The contractor shall have to do the sequencing of activities as per direction of engineer in charge to synchronize water pipe line, sewer and storm water pipeline work to minimize the road excavation and restoration in the street which will have two or all three pipe lines.

e) The cutting of existing C.C. pavement shall be done by using mechanical cutter to ensure cutting in regular line and the laying of C.C pavement shall be done below 30 degree ambient temperature.

i. Provisions of road restoration – Bituminous Road

a. For laying on B/T Surface - for road width up to 7 m, restoration up to WMM stage in trench width and bituminous work (top wearing surface) in full width of the Existing Road.

b. For road width more than 7 m, restoration up to WMM stage in trench width and bituminous work (top wearing surface) limited to 7 m (2 lanes) duly covering the trenches.

ii. Provisions of road restoration – Cement Concrete Road

a. For cement concrete roads, restoration of different layers including lean concrete and CC pavement shall be done in trench width only.

In Bituminous road restoration, Use of Paver is mandatory for carriage way width above 3.75 m of road restoration.

Notwithstanding all which has been laid down on road restoration, Employer's representative with reasons recorded and prior permission of Employer will be authorized to come up with the site specific solution based on prevailing ground situation.

7.17 Illegal Connections:

The Contractor based on the findings from the Consumer Survey and its GIS based analysis or another means, shall identify the illegal or un-authorized connections and inform employer for regularization of the connections. On approval and after payment of prescribed charges by the Consumer, the Contractor shall then rehabilitate the connection with the specification mentioned above. Until approval of regularization by employer, the Contractor shall prepare and send temporary bills at the prescribed tariffs for such illegal connections. The Employer will take a decision on this within a month's time from bringing to the notice. The contractor shall be more particular in bringing to the notice this list well in advance of commissioning new lines, as the old lines are to be made defunct.

7.18 Consumer Relation Management Centre

The Contractor shall design, develop and set up consumer relation management centre (CRMC) 1 no. of area not less than 40 m^2 and one Central Control Centre (CCC) of about 60 sqm to facilitate receiving and resolving consumer requests in the areas of new connections, service deficiencies, resolution of billing disputes, payment of bills etc. The consumers shall file their complaints through e-mail, text message from mobile phones, telephone, Fax and other electronic media. Contractor will maintain two toll free numbers each for water supply and sewerage/storm water drainage services at CCC. The Centres shall function between 8am to 8pm during all working days and between 8am to 1pm during public holidays including Sundays. The CRMC and CCC shall be air conditioned and have reasonable space and furniture for the Consumers to wait, interact and represent their requirements. During the other off peak times of 8pm to 8am, the Contractor shall have a facility to receive Consumer complaints through telephone, fax, text message, email and any other electronic means. The complaints once received should be acknowledged automatically and a registration number shall be given to the complainant immediately. The CRMC and CCC shall be equipped with sufficient human resources, hardware and software to facilitate continuous record of consumer requests, monitoring the resolution, and reporting completion of necessary actions and tasks.

7.19 Management Information System

Contractor shall develop, establish, operate and manage during the entire contract period a comprehensive Integrated Management Information System (MIS) in respect of all matters including but not limited to:

i. Design Built activities
ii. All the Operation and maintenance activities
iii. billings systems;
iv. Consumer services, including data bases relating to complaints and questions, response times and resolution;
v. Financial management, including accounting systems;
vi. Performance information systems; and
vii. Others as identified during SIP preparation and implementation.

7.20 Establishing Billing Systems

The Contractor shall:

i. Prepare and monitor the profile of water service Consumers in the Service Area describing consumer categories and other attributes collected through consumer survey in a GIS platform geocoded to the property footprints. The database and software shall be in a position to analyse the number of Consumers under each category, estimated average volume of water consumed per month, and estimated average revenue per month;

ii. Develop and implement basic Standard Operating Procedures for (i)service connections, (ii) preparing and issuing a bill for water service, (iii) how water consumption is estimated for Consumers meter under repair;

iii. Develop and implement: (i) meter reading procedures and arrangements, (ii) meter reader control, and (iii) efficient and accurate meter reading practices.

7.21 Operating Obligations

From the design, built completion date (which shall also mean sectional completion date, the Contractor shall supply potable water to the legal and authorized Consumers and operate and maintain sewerage & storm water drainage services through the laid and commissioned sewerage & storm water drainage system. Contractor shall be responsible for operation, maintenance and management of water supply sewerage and storm water drainage services in service area as detailed below:

No	Obligation	Period
1	Operating Intake works, Raw water system, Water Treatment Plant, Clear water pumping station to fill the UGSRs through transmission pipe, maintenance of system and maintaining the infrastructure	from final takeover date
2	Managing the distribution network for distributing water efficiently, equitably and minimizing non-revenue water (NRW) and maintaining the infrastructure on DMA basis	from final takeover date
3	Providing continuous pressurized water supply to the connected consumers and maintaining the infrastructure	from final takeover date
4	Meter reading, billing, bill distribution and customer services and maintaining the infrastructure in water supply sector	from final takeover date
5	Sampling treated water received at reservoir & consumer end to ensure that it meets the Potable Water Specification and monitor on regular basis;	from final takeover date
6	Detecting and monitoring non-revenue connections and consumption	from final takeover date
7	Contractor will provide continuous on-the-job trainings that will start from the day the contractor gets mobilized, and other capacity building programs by the contractor as important regular activities	from final takeover date
8	Operating and maintaining Sewerage network and Storm water drainage network in service area	from final takeover date

7.21.1 From Final Take over date to expiry of Operation Period of 5 years

i. Scope of Operation Services in water supply Sector:

- Operating Intake works, Raw water system, Water Treatment Plant, Clear water pumping station to fill the UGSRs through transmission pipe, maintenance of system and maintaining the infrastructure
- Managing the distribution network for distribution water efficiently, equitably and minimizing non-revenue water (NRW) and maintaining the infrastructure on DMA basis.
- Providing continuous pressurized water supply to the connected consumers and maintaining the infrastructure.
- Meter reading, billing, bill distribution and customer services and maintaining the infrastructure.
- Sampling treated water received at reservoir & consumer end to ensure that it meets the Potable Water Specification and monitor on regular basis
- Detecting and monitoring non-revenue connections and consumption
- Provide continuous on the-job trainings and other capacity building programs

If the Contractor fails to achieve the services defined in performance targets, then the Contractor shall be levied with Non-Performance Adjustment as specified in Schedule 4 & 5 of section 9 of PCC. The Contractor shall not be liable for Non-Performance Adjustment to the extent such failure is attributable to a Release Event in which event the Contractor shall take necessary steps to mitigate the effects of the event and operate the potable water system in accordance with the standards of a reasonable and prudent way.

Contractor will include costs for repairs of bulk flow meters, valves, panels, motor pumps and all other equipment and its spares including battery, and other equipment in his quoted price. Replacement of equipment, assets or infrastructure which is not part of the contractor's work or agreed in the SIP for replacement shall be paid separately.

ii. Scope of Operation Services in Sewerage Sector:

- Managing the sewerage network for collection of sewage including maintenance of entire system upto property chambers
- Billing, bill distribution, and customer services (as part of water supply bills)
- Provide house service connections on approval or sanction by Employer

If the Contractor fails to achieve the services defined in performance targets, then the Contractor shall be levied with Non-Performance Adjustment as specified in Schedule 4 & 5 of section 9 of PCC.

iii. Scope of Operation Services in Storm water drainage Sector:

- Managing the storm water drainage network for collection and discharge of storm water till outfall including maintenance of entire system including gully chamber/inlet gratings

If the Contractor fails to achieve the services defined in performance targets, then the Contractor shall be levied with Non-Performance Adjustment as specified in Schedule 4 & 5 of section 9 of PCC.

iv. Meter Reading:

The Contractor shall:

i. Read all consumer water meters in accordance with the general instructions of the Employer on monthly basis;

ii. Register all consumer water meter readings in the appropriate computer data base;

iii. Develop a monitoring program of random spot-checks to ensure the accuracy of the meters and the meter reading process and provide written reports to the Employer on the results;

iv. Develop and implement a plan; the intent of which is to ensure that:

   a. All consumer meters are in working condition

   b. all consumer meters are accurate,

   c. all consumer meters are read,

   d. all consumer meters are in suitable and easily approachable locations,

   e. problems related to unprotected and unsealed consumer meters are resolved,

   f. develop and implement a program to estimate consumption in circumstances where metering problems exist, and

   g. provide advice as to methods to improve the meter reading process to ensure greater accuracy;

v. Identify consumer meters which have not been read; and

vi. Respond to reports of malfunctioning consumer revenue meters from Consumers.

v. Billing responsibility

The contractor shall establish and operationalize billing system before commissioning the first Supply Zone.

Contractor shall generate the water and sewerage charges bills with the tariff decided by MCL. All bills will be processed, printed, collated, distributed and handled by the Contractor on behalf of and as an agent of Employer. All revenues shall be invoiced in the name of Employer. Collection of revenue is not included in scope of contractor.

The Employer shall have full and unrestricted access to the billing software, all current and historical billing data and the consumer service centres operated and managed by the Contractor upon request. All reasonable requests for data and analysis from the billing data system shall not be unreasonably refused by the Contractor.

vi. Meter Testing

The Contractor shall test and calibrate all water meters supplied and installed by the contractor as required.

If at any time either Party has reasonable grounds to suspect that any water meter is not accurate in any respect, the discrepancy or suspected discrepancy shall be immediately reported to the Employer in writing along with any evidence in support of such claim and the Contractor shall arrange for the testing of the relevant meter.

If any of the water meters fails to register or, upon testing, is found not to be within the accuracy standards established by the equipment supplier, or the latest revision of the Bureau of Indian Standards (BIS) or other relevant standard, then for the purposes of this Contract, a reasonable adjustment in accordance with

generally accepted engineering practices shall be made correcting all measurements, and reflecting, if determinable, the actual period during which any inaccurate measurements were made. If such period cannot be correctly determined, it shall be deemed to be equal to one-half of the time from the date of the last test of the meter or measuring equipment, provided that the period covered by the correction does not exceed six months.

The cost of all testing of the water meters shall be borne by the Contractor except in the case of testing carried out at the instigation of the Employer or Consumer which shall only be borne by the Contractor if such testing reveals the relevant meter to be inaccurate by more than 3%, and otherwise by the Employer or Consumer if within such accuracy standards. The testing shall be done in presence of Employer or its representative and consumer (*if he/she wish to be present*). The consumer shall be given advance information about the date and venue of testing. The test report shall be approved and authenticated by Employer or Employer's representative.

The consumer meter calibration using portable calibrated meter and without taking out the consumer meter from the service shall be essentially done after every two years and for this the continuous daily program shall be charted out. The observations shall be recorded and those meters which have gone beyond the accuracy limits, shall be serviced to reinstate the accuracy.

vii. Training

Contractor will provide on the job training during operation services to the staff of Employer. Such trainings will be commenced 30 days prior to commissioning the first DMA. Also that in the last year of O&M period and before 30 days from the date of handing over the assets back to the Employer, the Contractor shall organize detailed training to the identified staff in technical, commercial and financial aspects of water services provision to enable the Employer to build sufficient capacity and skills to manage the water services after the Contract Completion Date. Commencing from 30 days before the Contract Completion Date, the staff either from Employer or from a future Contractor will overlap and co-manage the operations to ensure continuity in service delivery.

viii. Electricity Consumption

The contractor shall be responsible to maintain the power factor for all the facilities installed by him during operation and maintenance period. Electricity connections at all proposed permanent installations will be applied by contractor and will be reimbursed to contractor. Power charges will be paid by the Contractor to the Electricity utility company. Penalty if any levied by the electricity company for not maintaining the power factor will be recovered from the contractor as per actual.

ix. Maintaining Performance Standards

The performance standards for the Design Build works during the SIP implementation shall consist of i) quality of work as per specifications and ii) The time line for completion as per the milestones defined . The liquidated damages will be levied for non-achievement of these milestones in time, as per the provisions in Section 9: Particular Conditions of Contract.

The measurement of the quality of work will be as per the tests laid down in the specifications of various items while the measurement of the achievement of milestones is based on the defined works and defined dates .

Payment of operation services will be in accordance to the procedures in Schedule 5 – Contractor Payments attached to Section 9: Particular Conditions of Contract. Operation service contract will be governed by Performance Standards provided in Schedule 5 – Performance Targets and Measurement attached to Section 9: Particular Conditions of Contract.

x. Periodic Reports

The Contractor shall prepare and submit periodic reports on different plans, progress of Works, performance standards etc., including exceptional reports on emergencies if any. The reporting requirements are provided in Table below. The Contractor shall as part of the SIP develop the required formats for the periodic reports and also identify any critical reporting requirements in order to enable timely decision making by the Employer.

Table 10:Summary of Periodic Reporting Requirements

Deliverable	First Report	Follow-up Tasks
Design Documents	Submit designs not later than 90 days from the Contract Commencement Date	Not applicable
Annual Operating Plan (AOP)	Submit Annual Operating Plan (AOP) not later than 90 days from the Commencement Date	Submit AOP for subsequent years not later than 90 days prior to end of previous year plan
Standard Operating Procedures (SOPs) for operation and management	Submit report not later than 360 days after Commencement Date	Complete implementation and training 30 days before commissioning of first zone and subsequently whenever new employees join for O&M.
Management Information Systems (MIS)	Submit report not later than 90 days after Commencement Date	Generate monthly reports from MIS
Operating Performance Report (OPR); the OPR shall include: a detailed progress report on the implementation of the designs; monthly water account with details of water supplied and received at DMA entry points ; billing details; Performance Standards achieved or maintained during the month; staff details engaged at various centres; exceptional reports on emergencies; financial	Submit OPR for any and every month before the 10th day of subsequent month commencing from the commencement date	To be submitted every month

Deliverable	First Report	Follow-up Tasks
information on project cash flows, grievance redressal of consumers, etc.		
Quarterly Performance Report (QPR); the QPR shall include a brief summary of the relevant issues detailed in the Monthly Performance Reports including a summary analysis of water supplies and lapses in billing, if any.	Submit Quarterly Performance Report for any and every quarter before 10th day of subsequent quarter commencing from the Commencement Date	To be submitted every quarter
Annual Performance Report (APR); the APR shall include the annual accounts, cash flow, and financial performance	Submit Annual Performance Report for any and every year before 20th day of subsequent year	Repeat for every year
Asset and Facilities Register	Submit Asset and Facilities Register within 150 days from the Commencement Date	Submit updated Asset and Facilities Register before 30th day from the completion of an operating year

7.22 DESIGN REQUIRMENTS FOR WATER TREATMENT PLANT

7.22.1 Water Treatment Plant Process Design Requirements

A 10 mld capacity water treatment plant is to be constructed under present scope of Tender. The scope of works includes carrying out topographical survey, investigations, planning of units, process, hydraulic and structural designs, provision of space satisfying the functional requirements for Mechanical, electrical and chemical building services and all other associated structures not limiting to treatment plant roadways and associated drainage, compound wall.

Construction of facilities, providing, installation and testing of equipment, instrumentation, electrical work and interconnecting piping, trials of completed plant, commissioning of plant performance, giving performance tests, and subsequent Operation & Maintenance for a period of five years are included in the scope work under this tender.

Information about the design details, extent of requirement of equipment, instruments, electrical work, interconnecting piping, specifications etc. are given in the Contract Document. Information furnished here spell out minimum requirement and is for the guidance of the tenderers. Tenderers in their own interest are advised to visit the Site and make their own assessment about the requirement of various items for satisfactory completion of the work.

Drawings etc. issued with this document are indicative only for the purpose of providing guidelines to the tenderers. The Tenderer should prepare process, layout, hydraulic drgs based on his design, site conditions and following the best engineering practices.

Work under the contract will be executed as per the 'Approved drawings', which will be prepared by the contractor and approved by Employer Representative. Contractors are advised to frame their proposal following the guidelines and by including mechanical & electrical equipments, electrical items, interconnecting piping and valves, SCADA, etc. as per the specifications given in the tender document.

7.22.2 Location

The land for construction of Water Treatment Plant (WTP) is identified adjacent to the Sidhwan canal. The land is bounded by Sidhwan canal on southern side, Railway line on North-west side & Pakhowal road on South-east side. Site plan for WTP is given in the tender for bidder's reference.

7.22.3 Recommended Design Norms

Treatment Facilities are to be designed as per design norms given in Manual on Water Supply and Treatment, Published by CPHEEO, Ministry of Urban Development, Government of India and /or similar publications accepted worldwide for design. The norms of some key units are described here below. Whatever stated here is minimum requirement. Bidder can adopt better values, if required, to achieve desired Clearwater quality from the plant.

Design of inlet and outlets of the units, interconnecting piping etc. shall be done with due consideration of recommended velocities/capacities for such structures. Shape of the units, length and widths ratios, floor slopes in case of conventional clariflocculators and of wastewater recovery/recycle system shall be selected with due consideration of recommended values in the Manual.

Design of electrical system, equipment, operating controls, etc shall be in conformity of Indian Electricity rules with relevant design code and as described in this tender document. Objective of Design and Detail

Engineering shall be to achieve desired treated water quality, smooth and maintenance free operation of the facilities and optimization on capital and O&M cost.

Table 11: Design Norms for Treatment Plant Units

Sr. No	Treatment Plant Unit and Design Parameter	Range Given in Manual	Recommended Value
1	Inlet Chamber		60 secs holding period
2	Parshall Flume (For flow measurement) and connecting Channels		Suitable for measuring flow up to 130% of design flow
3	Flash Mixing Tank		
	a) HRT	20 to 60 sec	45 sec.
	b) Power Input	1 to 3 watts/m^3/hr flow	1.8 watts/m^3/hr flow
4	Flocculation Tank a) HRT	10 to 40 min.	30 min
	b) Power Input	10 to 36 kW/ mld	25 kW/mld
	c) Velocity Gradient (G Value)	10 to 75 S^{-1}	35 -40 S^{-1}
	d) Area of paddle	10 to 25 % of cross section of tank	20 %
5	Clarifier (Conventional)		
	a) HRT	2 to 8 hours	2.0 hours
	b) Surface Loading	25 to 75 m^3/m^2/day	35 m^3/m^2/day
6	Rapid gravity Sand filter		
	f) Filtration Rate	5 – 9 m/hr	5.5 m/hr
	b) Backwash Rate	36 to 50m/hour	36 m/hr

Sr. No	Treatment Plant Unit and Design Parameter	Range Given in Manual	Recommended Value
	c) Air Scour	36 to 45 m /hour	36 m/hr
7	Chlorine Contact Tank HRT	20 to 30 min	30 min
	Dose		2 to 3 PPM based on Chlorine Demand
8	Filter backwash wastewater and Clarifier sludge recovery and recycle system	As per the design of the bidder with CPHEEO design norms wherever applicable.	

7.22.4 Design Considerations

Bidder shall take following into consideration in preparation of his proposal and for subsequent Designing and Detail Engineering in the event of his selection for the execution of the proposed work.

7.22.5 Raw Water Quality

The abstrcat of Raw water quality test report is provided in table below for bidder's refernec. Howvere, bidder shall get the water quality analysed independently before finalizing his designs and proposals. While designing system, due consideration shall be given to expected seasonal variation in the water quality.

Table 12: Raw Water Quality

Sr. No	Parameters	Unit	Value
1	pH	---	6.5 – 8.0
2	Colour	Hazen	4-7
3	Odour		Agreeable
4	Turbidity	NTU	10 to 100
5	Total Dissolved Solids	Mg/l	150 to 350
6	Total Alkalinity as CaCO3	Mg/l	100 to 200
7	Total Hardness as CaCO3	Mg/l	< 200

Sr. No	Parameters	Unit	Value
8	Chloride as Cl	Mg/l	< 100 mg/l
9	Nitrate as NO3	Mg/l	< 10 mg/l
10	Fluoride AS F	Mg/l	< 1 mg/l
11	Coliform count	MPN/100 ml	Up to 1000

7.22.6 Process Guarantees

Apart from the quality of the Clear water and the indicated water levels at the output and input of the plant the Contractor has to guarantee the following process performances for various flows over the years:

Table 13: Quality of Treated Water Process Guarantees

Turbidity of the effluent of the Clarifier unit prior to filtering	Not more than 5 NTU
Minimum filter run period at any time of the year between successive backwashing	24 hours
Maximum water losses in the treatment plant	1 % of the raw water input

7.22.7 Treated Water Quality

Facilities shall be designed so that the Treated water quality always meets drinking water requirement as listed in table 14 and 15**.**

Table 14: Treated Water Quality Requirements

Sr. No	Characteristics	Value
1	Turbidity (NTU)	≤1
2	Colour (Units on Platinum Cobalt scale)	5 or better
3	Taste and Odour	Unobjectionable
4	PH	6.5 to 8.5
5	Total dissolved solids (mg/l)	<500
6	Total hardness (as $CaCO_3$)(mg/l)	<200
7	Chlorides (as Cl)(mg/l)	<200

Sr. No	Characteristics	Value
8	Sulfates (as SO_4) (mg/l)	<200
9	Fluorides (as F) (mg/l)	<1.0
10	Nitrates (as NO_3) (mg/l)	<45
11	Calcium (as Ca) (mg/l)	<75
12	Magnesium (as Mg) (mg/l)	≤ 30
13	Iron (as Fe) (mg/l)	≤0.1
14	Manganese (as Mn) (mg/l)	<0.05
15	Copper (as Cu) (mg/l)	<0.05
16	Aluminum (as Al) (mg/l)	<0.03
17	Alkalinity (mg/l)	<200
18	Residual Chlorine (mg/l)	0.35 to .45
19	Zinc (as Zn) (mg/l)	<5.0
20	Phenolic compounds (as Phenol) (mg/l)	<0.001
21	Anionic detergents (mg/l)(as MBAS)	<0.2
22	Mineral Oil (mg/l)	<0.01
23	Arsenic (as As) (mg/l)	<0.01
24	Cadmium (as Cd) (mg/l)	<0.01
25	Chromium (as hexavalent Cr) (mg/l)	<0.05
26	Cyanides (as CN) (mg/l)	<0.05
27	Lead (as Pb) (mg/l)	<0.05
28	Selenium (as Se) (mg/l)	<0.01
29	Mercury (total as Hg) (mg/l)	<0.001
30	Polynuclear aromatic hydrocarbons (PAH)	<0.2

Sr. No	Characteristics	Value
	(mg/l)	
31	Pesticides (total, mg/l)	Absent
32	Gross Alpha activity (Bq/l)	0.1
33	Gross Beta activity (Bq/l)	1.0

Table 15: Bacteriological Quality Requirements

Organisms	Guideline value
Clear water entering the distribution system	
E.coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample

7.22.8 Treatment Requirement

It is envisaged that in order to achieve Treated water quality requirement for removal of following is provided:

- Turbidity
- Suspended Solids
- Coliforms
- Any other objectionable material

7.22.9 Hydraulic levels of Water Treatment Plant:

Raw water shall be extracted from Sidhwan canal by providing Intake arrangements. The details of canal near the intake location are provided in table below:

RD of canal	FSL	Bed Level
[1]72500	811.2 '(247.26 m)	805.2' (245.43 m)

Raw water shall be pumped to inlet chamber of Water treatment plant. The subsequent design levels of units shall be finalized based on the hydraulic and process design requirements.

[1] *The Details are provided for Bidder's reference. The exact RD of canal for Intake works shall be finalized after award of work.*

The proposed Plant shall be designed, selected and installed using process design parameter as specified in tender document and taking into account the site layout, site ambient conditions, local conditions and location.

7.22.10 Conceptual Treatment Scheme

Proposed Treatment scheme shall have at least following units:

Table 16: Proposed Treatment scheme

Treatment	Objective
Chemical House, Office and Lab coagulant dosing arrangement	Chemical storage and chemical feeding with provision of space to put additional equipments for future expansion.
Raw Water Inlet Chamber	To facilitate streamline flow in the subsequent channel
Pre Chlorination	For control of algae and microbes
Flow measurement	Fume should be capable of measuring Flow up to 15 MLD and should be designed according to IS 14371 / ISO 9826.
Flash mixer	For quick dissemination of coagulant in to raw water
Coagulation Flocculation and Settling	For removal of Turbidity Suspended solids
Filtration & Filter House	For controlling the presence of Residual Turbidity Residual SS Bacteria, Dead cells
Post Chlorination	For Disinfection of water
Recovery of water from clarifier sludge and filter back wash water and recycling the same	To re-use the WTP wastewater

7.23 Design for Clear Water Transmission Mains

The design of clear water transmission mains shall be based on the combination of optimum pump heads and pipe sizes vis-à-vis lengths of pipelines to be taken up for execution of works.

Table 17 : Design Criteria for Sizing of Transmission Pipeline

Sl. No.	Parameter	Parameter
1	Design Flows	As per demand analysis
2	Minimum Residual Head	3 m head of water
3	Design Horizon	30 years
3	Hazen Williams C-value for pipes	130 for Ductile Iron Pipes internally mortar-lined at factory for design year
4	Minor Losses	As per Actual Site Alignment subject to maximum 10% for design purpose over and above the major losses
5	Velocity	Not less than 0.6 m/sec and not more than 1.8 m/sec;
6	Pipe Class	For Pumping Mains discharging into UGSR –DI-K7 Pipe is to be used
7	Appurtenances	Requirement of Valves shall be got approved while submitting the designs, and provided in the transmission mains. Adequate care needs to be exercised during selection of location for valves, anchor blocks and thrust blocks so that there are no obstructions created by construction in the regular access for transport and movement of local populace.

7.23.1 Hydraulic Modeling for Transmission System Design

The Contractor shall develop a Hydraulic Network Model (HNM) for the raw water and clear water transmission system. The software used shall be 100% compatible with the GIS software. The HNM shall be built on contour maps of 0.5 m interval GIS maps. The data pertaining to water supply supply infrastructure like Reservoirs, Pump Stations, rising mains and transmission appurtenances viz. in line valves, scour valves, air valves, pressure points and flow measuring devices and demand allocations shall be suitably located and sized through field survey.

Following broad guidelines may be followed during hydraulic modeling for transmission mains:

- The hydraulic water use pattern for the day spread over 24 hours shall be provided by the Operator.
- The model prepared for finalizing shall be based on the EPS supply conditions and shall be run for 36 hours period.

- The storage capacities shall be modeled to verify the water level in various hours. It shall neither be empty nor overflow. The incoming flow at constant rate shall be decided accordingly. At all times from construction completion date when the water supply system will be commissioned up to contract completion date, all reservoirs being fed shall never get emptied and minimum water level in the reservoir shall be not less than **0.5 m, the flow** at the bulk flow meter is maintained at three times of the average flow without bypassing the reservoir.
- The hydraulic model shall be calibrated using set of observed data of pressure from sensors placed in transmission network at critical points of high and low pressures and flow from the bulk flow meters. The calibration of the transmission system model shall be a continuous iterative process. This model shall be used for the operation and management and while making decision for modification in the Bulk Supply pattern having its effect on the transmission network.

The model will be considered calibrated if the deviation between the output data and the measured values is less than 15% and improved on routine basis.

7.24 Hydraulic Modelling for distribution system

The Contractor shall develop a Hydraulic Network Model (HNM) for water supply, sewerage & Storm water drainage system. The HNM shall be built on contour maps of 0.5 m interval GIS map. The data pertaining to water supply infrastructure like Reservoirs, Pumping Stations, rising mains and distribution system , valves and demand allocations and pertaining to sewerage & Storm water drainage system like branch, lateral, trunk & outfall sewers/drains and other sewer line /drainage lines shall be obtained through field study and consumer survey captured on the network model using GIS.

The hydraulic network modelling by using latest software shall be carried out by collecting the actual property wise water demand allocated to the nearest junction. Following broad guidelines may be followed during hydraulic modelling:

- The junction shall be placed at the branching out/ at the crosses at the valves and where there is a large straight length at every 200 m. The model shall be worked out by considering the domestic demand as 150 lpcd water supply and actual demand for commercial and industrial requirement.
- The hydraulic water use pattern for the day spread over 24 hours shall be based on the survey data captured through consumer habits of water use in different hours at present and by following the standard pattern, after continuous water supply is successfully implemented.
- The storage reservoir capacities shall be modelled to verify the water level in various hours. It shall neither be empty nor overflow. The incoming flow at constant rate shall be decided accordingly.
- The DMAs which are still to develop where the present water requirement is quite less as compared to the design demand, the present scenario with existing water demand shall be run and the incoming flow shall be adjusted accordingly.

- The minimum pressure in the distribution network when full demand in the zone cum DMA is developed shall not be less than 17 m of water column at consumer meter point. The excessive pressure in the typical areas shall be managed using the appropriate pressure management techniques at distribution system level and other at the individual connection level.
- All new connections shall be marked on GIS map and captured as additional demand in the model and updated model.
- The hydraulic model shall be calibrated using set of observed data of pressure from sensors placed in distribution network at critical points of high and low pressures and flow from the consumer and bulk flow meters. The calibrated model shall be further validated using other set of live data. This validated model shall be used for the operation and management and while making decision for giving new connections and branches.

7.25 Design Criteria for Storm water drainage system

The Scope of Work shall include:

- Detailed Design, plans, L sections and construction drawings of storm water system of the project area
- Submission of design calculations, plans and drawings for approval to the client
- Construction of storm water Network as per approved design and plans
- Erection, Testing, Commission and O&M of the system

Storm water collection systems shall be designed to provide adequate surface drainage. The new network shall be integrated with existing Trunk Strom water drainage network of service area. The general considerations in design of storm water drain shall be:

- Drains shall be design for appropriate design frequency/return period depending on importance of development and economic considerations.
- Drains shall be planned taking into consideration the ground levels, slope of the ground, valley and ridges and also the land uses planned for urban development.
- Drains shall be planned to get good longitudinal slope, considering the nature of soil and subsoil water level.

7.25.1 Return Period

The frequency of storm for which the drainage system is to be designed depends on the importance of the area and it is a general practice that the public areas and commercial areas/ high priced areas need to be protected from the flooding.

The frequency of storm/ Return period shall be considered as mentioned in table below:

S.NO.	Type of Drain	Return period (T) in years
1	Secondary/ tertiary/ road side drains	1
2	Primary/ Natural drains	2

7.25.2 Rainfall Intensity

The contractor shall collect/purchase authenticated daily rainfall data for at least last 30 years to prepare the IDF curve. The IDF curve shall be approved by Employer representative before start of design of storm water network.

7.25.3 Design Velocity

To ensure self-cleaning of the drain, a minimum velocity of 0.75 m/ s is recommended. The velocity of flow in a drain shall not be too great to cause excessive scouring or hydraulic jumps. Hence as per maximum velocities shall be limited to 2.5 m/sec

7.25.4 Inlet Spacing

The spacing of inlets depends on condition of road surface size and type of inlet and rainfall. They shall be provided at closer intervals near junctions and valley curves; however maximum spacing shall not be more than 30 m.

7.25.5 Design methodology

Rational Method

Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff is dependent on the intensity and duration of rainfall, characteristics of tributary area and the time required for such flow to reach the drain. The peak runoff rates shall be calculated using the Rational method. The formula is:

Q = 0.00278 CIA

Where:

Q = flow, m^3/s

C = weighted runoff coefficient

I = rainfall intensity in mm/hr

A = drainage area in hectares

Runoff Coefficient

The runoff coefficient, C, in Equation is a function of the ground cover and a host of other hydrologic abstractions. It relates the estimated peak discharge to a theoretical maximum of 100 percent runoff. Typical values for C are given in table below. If the basin contains varying amounts of different land cover or other abstractions, a composite coefficient shall be calculated through area weighing using Equation below:

Weighted C = Σ(Cx*Ax)/Atotal

Where:
x = subscript designating values for incremental areas with consistent land cover

Runoff Coefficients for Rational Formula

Type of Drainage Area	Runoff Coefficient, C
Playgrounds	0.30 – 0.40

Type of Drainage Area	Runoff Coefficient, C
Non concrete	0.30 – 0.40
Asphaltic	0.90 – 0.95
Concrete Pavements	0.90 – 0.95
Brick	0.80 – 0.85
Roofs	0.90 – 0.95

Hydraulics

The size of the drains shall be determined using Manning's formula. The Manning's equation is given below:

$$Q = (A\ R^{2/3}\ S^{1/2})/n$$

Where,

Q = discharge capacity of the drain in m^3/s

N = manning's roughness coefficient

A = flow area in m^2

R = A/P = hydraulic radius in m

P = wetted perimeter in m

S = channel slope

Cover and Frame

As per IS-4111: 1986, the size of manhole covers should be such that there should be clear opening of not less than 560 mm diameter for manholes exceeding 0.9 m depth.

Manhole cover and frame will be SFRC (Steel Fiber Reinforced Concrete) conforming to the IS 12592

Manhole Type	Load withstanding capacity	Suitable Locations
L.D (Light Duty)	2.50 MT	Footpaths, Two wheelers
M.D (Medium Duty)	10.00 MT	Light four wheelers
H.D (Heavy Duty)	20.00 MT	Heavy vehicles
E.H.D (Extra Heavy Duty)	35.00 MT	Heavy traffic roads

7.26 Structural Design Requirements

This section specifies the Design requirements pertaining to Civil RCC Structural works. The Civil General Technical Specifications and Standard Specifications included in the tender shall be read in conjunction with these requirements.

7.26.1 Design Submissions

The Contractor shall submit 5 (Five) copies of complete detailed design calculations of each of the components such as substructure and superstructure together with general arrangement drawings, construction drawings and explanatory sketches as required by the Employer. Separate calculations for substructures or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Employer.

The design considerations described hereunder establish the minimum basic design requirements of plain and reinforced concrete structures, architectural details, masonry structures **and structural steel works.** However, any particular structure shall be designed for the satisfactory performance fulfilling the functions for which the same is being constructed. The Contractor shall also check the stability of completed structures to be used for the project.

7.26.2 Design Standards

All designs shall be based on the latest Indian Standard (I.S.) Specifications or Codes of Practice. The design standards adopted shall follow the best, modern and sound Engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Employer's Representative.

All the designs of reinforced concrete structures shall generally confirm to the recommendations made in the following publications (latest versions) of the Bureau of Indian Standards:

i. IS : 456: Code of Practice for plain and reinforced concrete

ii. IS: 875: Code of Practice for design loads for buildings and structures other than Earth Quake loads (Part 1 to 5).

iii. IS: 3370: Code of Practice for concrete structures for the storage of liquids (Part I to IV)

iv. IS: 1893: Criteria for earthquake resistant design of structures.

v. IS: 2974 : Code of Practice for design and construction of machine foundations (Part 1 to 4)

vi. IRC: 6 Part II :Standard specification and Code of Practice for road bridges Loads and Stresses

vii. SP: 34: Handbook on concrete reinforcement and Detailing.

All structural steel design shall generally conform to the following recommended latest publications of the Indian Standards Institution:

i. IS : 800 :Code of Practice for general construction in steel

ii. IS : 806 :Code of Practice for use of steel tubes in general building construction

7.26.3 Design Life

The minimum design life of all structures and buildings shall be 60 years.

7.26.4 Design Loads

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; which includes dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads.

7.26.5 Dead Load

This shall comprise loads arising due to all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipments and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding its contents.

The minimum Dead Loads shall be as per IS: 875 (Part 1).

7.26.6 Live Load

Live loads shall be in general as per IS: 875 (Part 2). However, the following minimum loads shall be considered in the design of structures:

i.	Live load on roofs	: 1.50 kN/m^2
ii.	Live load on floors supporting equipment such as pumps, blowers, compressors, valves etc.	: 10.00 kN/m^2
iii.	Live load on all other floors, walkways, stairways and platforms.	: 5.00 kN/m^2

In the absence of any suitable provisions for live loads in I.S. Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Employer's Representative prior to starting of the design work. Apart from the specified live loads or any other load due to storage of materials, any other equipment load or possible overloading during maintenance or erection/construction in part or full, most critical condition shall be considered in the design.

7.26.7 Wind Load

Wind loads shall be as per IS: 875(part 3).

7.26.8 Earthquake Load

This shall be computed as per IS: 1893. The project area falls in seismic zone 2.

7.26.9 Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, traveling cranes, etc. shall be considered in the design of structures.

7.27 Mechanical Design Requirements

7.27.1 Horizontal Split Casing Centrifugal Pump

The contractor shall select suitable pumps for operation of clear water pump in the specified operating range. All the pumps shall be of similar characteristics at every pump station.

The type of pumps shall be Horizontal Split Casing type & all the pumps shall be provided with suitable motors and accessories.

The static head for the design of clear water pumps at pump Station will be the difference in centre line of inlet at CWR and highest water level in the UGSR.

The pump shall have a stable head curve, i.e. the total head-capacity curve shall be continuously rising towards the shut off head. The shut off head shall be at least 10% more than pump head at intersecting point of the pump curve with the upper range system head curve.

A minimum overall (combined) efficiency as 72% for each clear water pump set and motor selection shall be made.

The required pump NPSH at duty point shall be at least 0.5 meters less than the available NPSH. The horizontal split casing pumps shall be used with positive suction head.

Pump must be suitable for operating in parallel over the entire operating range. The pump shall operate satisfactorily at any point between the maximum and minimum system resistance.

The pumps shall be capable of reverse rotation up to 125% rated full speed of the drive motor, due to back flow of water, without damage or loosening of threaded components.

The specifications for flanges shall be as per the relevant IS code.

Spare parts supplied with the pump shall be identical to respective pump components and shall be from original manufacturer.

Pumps shall run smooth without undue noise or vibration. Noise levels and velocity of vibrations shall be within acceptable limits. Noise level shall be limited to 85 dba at a distance of 2 m. Velocity of vibrations shall be within 4.5 mm/s as per relevant Hydraulic Institutes Standards and IS.

Unless otherwise specified the drive unit power rating shall be the maximum of the following requirements:

A. Required margin/factor as given below over the pump shaft input power required at duty point.
   - Pump shaft input power 15-75 KW - 1.20
   - Pump shaft input power>75 KW - 1.20

B. Pump shaft input power at (-) 25 % of duty head.

C. Pump shaft input in the operating range corresponding to minimum & maximum water level in the CWRs

7.28 Electrical Design Requirements

7.28.1 Major Electrical Components of the Contract

The following is a brief description of the major components of the Contract. This is to be complemented and read with the details provided in the subsequent subsections of this document.

The works component included are as defined below but shall not be limited to:

7.28.2 Raw Water Pumping Station, 10 MLD Water Treatment Plant and Clear Water Pumping Station

11kV outdoor substation consisting of lightning arresters, current transformers, voltage transformers, dis-connectors, fuses, insulators, ACSR conductor, clamp and connectors with necessary metering and protection arrangement including steel structure.

1. 11/0.433 , Dyn11, ONAN transformers with OCTC

2. VFD for LV motors
3. Starters for LV motors
4. LV Switchboard/ Distribution Board/ Lighting Panel
5. Local Push Button Station
6. HV and LV cables
7. LV capacitor with APFC panel
8. Lighting system
9. Cabling system
10. Earthing and lightning protection system
11. Diesel Generator with PLC Based AMF

7.28.3 Proposed Water Distribution Station at Leisure Valley and Rose Garden

11kV outdoor substation consisting of lightning arresters, current transformers, voltage transformers, dis-connectors, fuses, insulators, ACSR conductor, clamp and connectors with necessary metering and protection arrangement including steel structure.

1. 11/0.433 , Dyn11, ONAN transformers with OCTC
2. VFD for LV motors
3. Starters for LV motors
4. LV Switchboard/ Distribution Board/ Lighting Panel
5. Local Push Button Station
6. HV and LV cables
7. LV capacitor with APFC panel
8. Lighting system
9. Cabling system
10. Earthing and lightning protection system
11. Diesel Generator with PLC Based AMF

7.29 Instrumentation, Automation and Control System Design Requirements

7.29.1 Design Requirements for Instrumentation, Control, Automation and SCADA Systems

The instrumentation, control, automation SCADA installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer.

7.29.2 General Design Requirements

a) Instrumentation and Control system shall be designed, manufactured, installed and tested by an experienced system integrator to ensure high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

b) All I&C equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain and temperature variation from 0 to + 50^0 C. Wherever necessary, space heaters, dust and waterproof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories. The control equipment installed inside the control room should be designed to work at 35^0 C and the instruments in sheltered place outside the control room at 45^0 C.

7.30 PARTICULAR TECHNICAL REQUIREMENTS – WATER TREATMENT PLANT

7.30.1 New Water Treatment Plant Process Technical Requirements : General Arrangement of the Works: Site Development

The land for construction of Water Treatment Plant (WTP) is identified adjacent to the Sidhwan canal. The land is bounded by Sidhwan canal on southern side, Railway line on North-west side & Pakhowal road on South-east side. The finished ground level for the plot shall be finalized based on the hydraulic design of the WTP submitted and approved. A 10 mld capacity water treatment plant is to be constructed under present scope of Tender.

The scope includes Design and Construction of New Water Treatment Plant of 10 mld capacity and subsequent Operation and Maintenance of plant for a period of five years after Design Build period (Construction). Construction of all required facilities as per approved drawings, by providing material, equipment, manpower whatsoever required for timely completion of work.

Bidders Scope will broadly consist of, but not restricted to following.

I. Unit processes and services

- Intake works
- Raw water main and pumping station
- Raw Water Inlet Chamber
- Raw Water Channel
- Flow measuring device
- Coagulant addition and flash mixing Tank;
- Distribution Chambers
- Clari-flocculators / Tube-settlers

- Rapid Gravity Sand Filters & Filter house Building
- Pre and post chlorination system, including all accessories.
- Chlorine Contact Tanks
- Wastewater handling system

  a. Filter backwash holding tank

  b. Clarifier sludge recirculation system

  c. Mechanical sludge dewatering system

  d. Storage facility for dewatered sludge

  e. Recovered water storage tank and pumping for recycling

  The process of wastewater recovery system is indicative only. The bidder may offer his own design based on his experience.

  The mechanical sludge dewatering shall be deigned based on maximum of 16 hrs of operation.
- Chemical House, Laboratory & Office Building
- Chlorinator Shed
- Chlorinator Room
- Internal roads & pathways
- Interconnecting ducting & water channels
- Coagulant dosing arrangement.
- Air Blower
- Connecting pipe from post-chlorination to clear water reservoir

II. Civil and Building works for

- RCC structures for the aforementioned processes;
- Piping and conveyance systems
- Treatment plant roadways and associated drainage;
- Operation, maintenance and management of the treatment plant.
- Electrical power, control and instrumentation SCADA and Automation systems
- Mechanical systems.
- Mechanical, electrical and chemical building services.

The Works shall include but not limited to:

- process and hydraulic design;
- design and construction of all civil structures and building works;

- design and manufacture, supply, testing at manufacturers' works, storage when required, delivery to site, unloading and site transportation, erection, site testing, painting and finishing of the Plant;
- water testing and commissioning of the water treatment plant;
- Provision of spare parts, special tools, operation and maintenance manuals and As-Built drawings;
- Provision of training for the Employer's personnel.
- Operation and maintenance of the complete water treatment plant

III. Designing, manufacturing/procurement from approved vendor, transportation to site, installation testing and commissioning of equipment in proposed water treatment facilities, as per the specifications. This will include but not restricted to following

1. Agitator For Flash Mixing
2. Mechanism for Flocculation Cum Settling Tank (Clariflocculators/tube-sellers)
3. Air Blowers for filter backwash
4. Chlorination system & accessories
5. Clear Water Pumps for Back wash
6. Agitator for Chemical mixing
7. Filter Backwash storage tank with mixing arrangement
8. Mixing arrangement for Clarifier sludge/Tube Settler sludge
9. Mechanical sludge dewatering system including pumping of thickened sludge and addition of chemicals, if any.
10. Transfer pumps for recovered water

IV. All the operations of the water treatment system shall be controlled through a well planned SCADA system supported by PLC

V. Designing, manufacturing/procurement from approved vendor, transportation to site, installation, testing and commissioning of control instrumentation as per specifications.

VI. Designing, manufacturing/procurement from approved vendor, transportation to site, laying, jointing testing and commissioning of valves, pipes and pipe fitting as per specification and description given in the Tender.

VII. Designing, manufacturing/procurement from approved vendor, transportation to site, installation, testing and commissioning of Motor Control Center (MCC) for controlling operations of al electrical equipment in the water treatment plant as per specifications and description given in this Tender.

VIII. Designing, procurement from approved vendor, transportation to site, laying, jointing, testing of electrical and instrumentation cables in the proposed water treatment plant as per description and specifications given in this document.

IX. Providing Five (5) sets of test data & certificates for tests carried out on equipment, Electrical motors, instruments etc. at manufacturer's shop.

X. Providing Five (5) sets of operation, installation and maintenance manual along with necessary drawings for each of the equipment, Motor control Center, Instrument, etc.

XI. Conducting performance trials of the water treatment facilities for a period of three months, by providing skilled and unskilled labour, chemicals, lubricants, etc. to demonstrate the functioning of plant in general and performance of individual units and equipment items in particular.

XII. Giving performance tests of all equipment, electrical work, instrumentation, interconnecting piping etc. for a 144 Hours continuous operation at duty conditions.

XIII. Providing free of cost replacements and services for repairing the defective equipment, electrical work, and instrumentation, interconnecting piping etc., during Defect Liability Period of the Contract.

XIV. Providing operation and maintenance services, for a period of 60 months from the date of completion of work in all respect and successful completion of 144 Hours performance test, by providing all consumable like chemicals, lubricants, skilled and unskilled manpower, supervision, and laboratory analytical services, etc.

XV. A properly designed PLC system along with required instrumentation and provision for manual operation of the plant from operating console.

7.30.2 Scope of work

The Scope of works also covers following preliminary works to be undertaken by the Contractor:

- Based on the site visits, the Contractor shall carry out preliminary surveys/ confirmatory surveys to the satisfaction of the Employers Representative and prepare necessary working drawings and maps.
- On the basis of survey carried out temporary/permanent bench marks shall also be established for reference during working
- Contractor shall also arrange for taking trial pits and test for SBC's of the strata
- Contractor shall also arrange for necessary labour and materials for carrying out of the works.
- The work shall be executed conforming to the approved designs and drawings and detail and levels to the perfect line and plumb in a highly professional manner. The work shall progress successively as per the schedule / bar chart to be got approved before the commencement of the works.
- Monthly progress of the work shall be reported to the Employers Representative along with all other detail such as material consumption, test reports etc.

- As the works gets completed, all the record drawings / as built drawings shall be submitted to the Department.
- Necessary inspection of material/equipment's, as per category shall be carried out well in advance.
- The payment for confirmatory survey, laboratory test, factory and performance tests, testing and commissioning shall be as per bid conditions. Wherever any survey or investigation is not mentioned specifically, the same shall be deemed to be included in the rates and prices of the physical works itemized and quantified in the bill of quantities. The payments are to be made for all supplies and physical works described in the bill of quantities according to the measured and agreed quantities executed.

7.30.3 Orientation

The Works shall be laid out within the confines of the Site in order to interface logically to the existing infrastructure of roadways and inlet and outlet pipework. Underground services (whether physically located on the Site or not) requiring to be relocated in order to accommodate the proposed site layout shall with the approval of the Employers Representative be relocated by the Contractor.

7.30.4 General Arrangement of Plant

The following general rules shall be followed in arranging the Plant units:

- sufficient room (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance; for provision of appropriate structure foundations
- an area adjacent to all mechanical Plant shall be provided as a maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant Equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with covered drainage channels which shall direct spillage either to a suitable drain or to a sump from where it can be pumped to drain.
- plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements;
- plant shall be arranged and the building designed to permit the removal of Plant items. Since the interconnecting conveyance channels of the plant are to be designed for excess capacity in anticipation of future plant expansion, the plant shall be laid out such that there is space provision for future expansion units.
- all the units shall have drain valves. The drain valves of diameter less than 250mm shall be manually operated and higher than 250mm valve shall be electrically operated. For the valves located below ground level extended spindle shall be provided for ease of operation.
- Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

- All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it shall be supported not less than 150 mm clear of the floor.
- When selecting materials for pipework, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight.

7.30.5 Inlet to Works

Raw water shall be drawn from Sidhwan canal near to proposed WTP location. Raw water shall be carried to the sump of proposed Raw water Pump Station of WTP by open channel/pipeline having capacity to meet ultimate water demand, 12 MLD + 20% and pumped to the proposed WTP.

7.30.6 Brief Description and Specifications for Treatment Plant Units

General

The WTP shall be designed for gravity flow from Raw Water Channel based on Constant/Declining rate of filtration. Lay out shall be such that minimum 2 m space is maintained between two units and appropriate pathways and approaches are provided for each and every treatment plant unit. All interconnecting piping from one unit to other shall be laid below ground. Pipe and valves should not obstruct the approach pathways. Interconnecting pipes, valves on the pipes and channels shall be designed to carry 20% excess flow over normal design flow. Inlet and outlet of all the plant units shall also be suitable for passing 20 % excess hydraulic flow without adversely affecting the treatment process. Work under this contract shall be carried out as per approved designs, drawings. Contractor will submit drawings along with design calculations reference codes, etc. for approval of Client. Proposal shall be framed in line with salient specifications given in this tender document. Following ranges of designs are indicative and contractor shall design & propose units of WTP based on constant/declining rate filtration.

7.30.7 Inlet Chamber

Raw water pumped from Raw water pump station shall first be received in Inlet Chamber, with detention time of 60 seconds at the maximum rate of flow, Purpose of this tank shall be to dampen the disturbances due inlet and facilitate near streamline flow in the channel leading to flow measuring device and then to flash mixer.

7.30.8 Flow Measuring Device

Flow measuring device shall be a Parshall Flume with ultrasonic flow meter to measure the levels. An indicator giving instant flow shall be installed near the Flume, while the indicator and integrator shall be mounted in remote control panel/PLQ panel as well as in the SCADA. The Flume should be designed to measure minimum 130 % of design flow.

Pre-chlorination pipe line shall be provided to channel before flash mixer. Dosing of chlorine should be done as recommended in CPHEEO manual. Prechlorination shall be practiced only during the time the raw water contains microbiological contaminants that may interfere with normal operation of filtration or may have excessive coliforms or suspected bacterial contamination or has colour/foul odour. The prechlorination system should be capable of providing dosage of up to 5 mg/l.

7.30.9 Flash Mixer

A flash mixer shall be used to intimately mix the coagulant and the raw water as rapidly as possible. The flash mixing shall be done in a stirred tank constructed from reinforced concrete, rectangular in cross-section. Flash Mixing Tank shall be designed for retention time of 40-60 seconds. All internal and external surfaces of the Tank shall be provided with 20 mm thick smooth cement plaster in 1:4 CM. All internal surfaces shall also be provided with food grade epoxy paint. Inlet and outlet to flash mixer shall be designed so as that velocity of water flow remain in the range of 0.6 to 0.8 m/sec. Flash Mixing Tank shall be provided with suitable electrically operated mixing device.

The flash mixer design shall be such that short-circuiting is minimised and the coagulant is thoroughly mixed with the water in the flash mixer. Also there shall be perforated baffle at the Flash Mixer inlet zone, so as to avoid direct hydraulic shock to the Flash Mixer Impeller.

7.30.10 Agitator for Flash Mixer Tank

Electrically operated, Vertical top entry type, slow speed, propeller or turbine mixer shall be provided in Flash mixing Tank. Impeller diameter shall not be below 30 % of the tank diameter. Mixer should be able to create velocity gradient of 450-s. Power input shall be in the range of 1.5 to 3 watts /m3/hour flow.

The mechanical equipment for flash mixers shall comprise stainless steel (SS-316) agitating paddles fixed on stainless steel (SS-316) shaft with thrust bearing support, driving gear consisting of a motor coupled to a reduction gear of appropriate ratio. The motor and gear box arrangement shall be appropriately covered and any spillage of oil from the gearbox shall be prevented from entering the raw water. Electrically operated Sluice Gates shall be provided to isolate each of the duty and standby flash mixers.

Motor, gear box and chain pulley assembly shall be provided with proper covers and shall be suitable for installation in open to sky condition. Electric motor shall be suitable for operation on three phase 415 V AC supply. Motor shall be TEFC with 'B' class insulation and IP 68 protection.

7.30.11 Distribution Chamber

A reinforced concrete chamber shall be provided at the outlet of the flash mixer to receive the raw water from the flash mixer and to convey the same by gravity to the individual rows of flocculator clarifiers via adjustable weirs or to bypass the clariflocculators and deliver the water directly in to clarfied water channel, leading to filtration plant. The chamber shall be designed to minimise turbulence in the chamber and flow shall be provided with overflow facilities. The overflow shall be conveyed by gravity to the nearest /drain. The Contractor shall supply and install adjustable weir plates in the chamber to control flow to the clarifiers and for the overflow. The Contractor shall supply facilities to detect high water level in the chamber.

The contractor shall provide appropriate numbers of electrically operated sluice gates in the distribution chamber in order to ensure the flow control to the Clarifier and by-pass the flow to the filter unit.

7.30.12 Chemical House

Chemical House shall be minimum 2 storey and shall meet following requirement

I. Storage Tanks (minimum 2 nos for each type of coagulant/chemical proposed as per bidder's design) constructed in RCC lined with Acid proof tiles and having minimum Storage for two months requirement

II. For housing Dosing Equipment

III. Chemical House shall be a RCC Frame structure with Brick walls.

IV. Provision shall be made to provide space for dosing pumps for coagulants/chemicals (as per bidder's design) and control panel etc. near the Storage Tank.

V. Dosing of coagulants / chemicals shall be through constant rate dosing Pumps or by gravity from storage tanks using rotameter

VI. Due consideration shall be given to provide suitable architectural features to building. All door and windows frames shall be in heavy gauge aluminum. Window panes will be in glass in aluminum frame.

VII. Provision of specification of fan, light, toilet shall be made for the rooms. Provision for sufficient nos. of exhaust fans shall be made for chemical store.

Sump Pumps

A sump pump complete with all associated pipework, valves and fittings shall be supplied and installed in the chemical house to pump leakage and drainage water to the foul drainage system. The sump pump shall be of the submersible type and shall be complete with hard wired level controls for automatic start/stop. An alarm shall be raised if the level in the sump becomes high.

7.30.13 Clariflocculator

Minimum two Nos. Clariflocculator (Flocculator cum Settling tank) shall be provided for effective coagulation, flocculation and settling. Clariflocculator shall be a RCC water retaining structure. Each tank shall be designed for passing half of the normal design flow. Surface loading rate in settling tank shall not exceed 35 m /hour. HRT in settling zone shall not be less than 2.0 hours. Flocculation zone shall provide detention time of minimum 25 minutes. All internal and external surfaces shall have 20 mm thick water proof plaster in 1:3 CM laid in two layers. Floor of the tank shall have 1 in 12 slope form periphery to Centre. Floor shall be provided with 50 mm thick screeding in CM. Flocculators and Sludge scrapping mechanism shall be fitted in clari-flocculator. Flocculation zone shall be separated from Clarifier zone by RCC baffle. Adjustable overflow V notch weirs in SS or FRP shall be provided in clarifier. Length of the weir shall be sufficient so that the loading rate at normal flow does not go beyond 300 m3/m/d. Design of flocculation and clarification shall be such that the clarified water shall not have turbidity above 5 NTU.

7.30.14 Specifications Flocculation cum Settling Tank Mechanism

Flocculator

Quantity	Two sets (In each tank)
Location	Flocculation cum settling tank Clariflocculator
Type	Peripheral driven extended half way rotating Bridge,
Flocculator Speed	3 to 4 rpm
Accessories	Walkway on Bridge with, handrail, Flocculation chamber, flocculators, Prime mover, reducer, brass/neoprene rubber squeegees, etc.
Duty	Flocculation of colloidal material and Scrapping of chemical sludge accumulated on the floor of the tank

Epoxy (Food grade) painted flocculation chamber will be concentrically placed in the tank.

7.30.15 Sludge scrappers

One set of sludge scraping mechanism shall be installed in each of the Flocculation cum settling tank. Mechanism shall be suitable for installation in RCC tank provided for flocculation and settling.

I. Scope

Vendor shall include the following in his scope

Design, manufacture, supply transportation to site and erection and testing of One set of sludge scraping mechanism and suitable numbers of flocculators in each of one RCC tanks as described above complete with following :

- ✓ Complete drive arrangement for sludge scraping mechanism including motor, gear box, drive head upper and lower bearing, turn table and all other components required for satisfactory functioning of drive mechanism.
- ✓ Two numbers of flocculation mechanism for installing in to flocculation chamber that is concentrically placed in the RCC tank.
- ✓ Extended half-length walkway bridge and support arrangement for Flocculators/scraper mechanism including handrail, etc.
- ✓ Sludge scraper arms, squeegees etc. of appropriate material.
- ✓ All nuts, bolts, fasteners, etc. required for assembling the mechanism and for placing it in the tank.

Vendor shall provide three sets of operation, installation and maintenance manual along with necessary drawings.

II. Specifications

i. Bidder shall offer centrally driven mechanism. Mechanism of approved make shall only be acceptable. The Design offered shall be proven one.

ii. Motor, gear box and chain pulley assembly shall be provided with proper covers and shall be suitable for installation open to sky.

iii. Electric motor shall be suitable for operation on three phase 415 V AC supply. Motor shall be TEFC with 'B' class insulation and IP 68 protection.

iv. Scraper arms, central rotating cage/ shaft, feed well, walkway and mechanism support shall be MS fabricated structure, fabricated from tested quality steel as per relevant IS code. All submerged part shall be provided with two 75-micron thick coats of zinc rich epoxy primer and two finish coats of 75-micron thick coal tar based epoxy paint. Structure above water level shall be provided with two coats of red oxide primer and two finish coat of synthetic enamel paint of approved shade and make. Feed well shall be in RCC.

v. Wherever painting is recommended, only primer shall be applied in the manufacturer's workshop. Topcoat shall be applied at site on completion of erection work.

vi. Squeezes shall be of brass or neoprene rubber. Entire mechanism after installation in tank shall be tested in dry condition. It shall be designed and fabricated for non-fouling

and noiseless operation in tank. Vendor shall have to rectify manufacturing defect noted at any time after installation of mechanism in tank.

vii. Flocculator paddle area shall not be 10- 25 % of cross section area of flocculation Zone. Mechanism should be able to create velocity gradient of 40-45 $^{-s}$.

viii. All fasteners, nuts-bolts shall be of high quality GI material.

7.30.16 Filters & Filter House

Appropriate numbers of Rapid Sand Gravity filters (**Operating in Declining/Constant Rate Filtration mode**) shall be provided for filtration of water at specified filtration rate. Filters shall be of constant/decline flow rate type. Filter box and ancillaries shall be in RCC construction. Provision for air scouring during back wash operation shall be provided. Air scouring and back wash water flow rate shall not be less than as indicated under recommended design norms. Provision of backwashing entire filter bed (both the beds if twin beds are proposed) at one time shall be provided. Wash water gutters, air inlet, wash water inlet, drain etc shall be adequately sized. Ratio of length and width of filter shall be in conformity with standard design practice. Filter beds and filter operation gallery shall be covered RCC frame structure. Provision for special Architectural features of Filter House shall be made. Back wash shall be carried out through backwash pumps. Suitable structural design shall be done. No of filter unit shall be such as to make one bed will be available whenever one unit will backwash. Other details of design shall be as per CPHEEO manual.

Filter media shall be confirming to IS 8419 (part D) latest version. Uniform size single media is recommended for filtration design. Effective size of sand shall be between 0.55 to 0.75 mm having uniformity coefficient between 1.7 and 1.3. Silica Content of the sand shall not be less than 90%. Depth of sand bed shall be so designed as to achieve best possible removal of turbidity and microorganism from the water. Depth of sand bed in filter shall not be less than 900 mm. The filter sand shall be supported gravel and coarse sand supporting media of suitable depth. Water depth in the filter box should be minimum 2 m.

The Declining filters should be operating at average rate of 6m3/m2/hr. Maximum flow rate through a freshly washed filter should not exceed 9m3/m2/hr while flow rate through the filter next in line for backwash should not be less than 3m3/m2/hr. Control of maximum flow through the filter may be achieved by placing a fixed orifice in the common outlet pipe of each filter.

In case of constant rate filtration, the rate of flow shall be 6 $m^3/m^2/hr$. And rate of flow shall be controlled through flow rate controllers placed at the outlet of each filter.

Contractor will have to take approval about source of filter media before procurement. Contractor shall be required to make arrangement for analysis filter media from selected source in a recognized and approved laboratory. Client will draw sample of filter media from each supply and get it analyzed in laboratory of his choice. Media not conforming to IS 8419 shall be rejected.

Contractor will have to make arrangement for proper storage of media after receipt at site so as it does not get contaminated. Placement of media on filter bed shall be done in an orderly manner under expert supervision and as per guidance provided in CPHEEO Manual. After placement of media on filter bed all construction activities in the surrounding of filter bed shall stop. In case any work is being carried out in the vicinity of the filter due care shall be taken to cover the filter bed. Media shall be thoroughly washed before putting to use.

One filter run shall not be less than 24 hours. Filter Outlet water shall have turbidity below 1.0 NTU in all seasons.

All control valves for each filter bed shall be motorized. Sizing of pipes, valves and pumps shall be done by giving due consideration to recommended velocity at each port. Operation of filter shall be automatic based on PLC system. A properly designed PLC system along with required instrumentation and provision for manual override shall be provided to facilitate the automatic operation of the plant from PLC or manual operation from operating console. Start signal for backwash shall be taken from flow sensing instrument placed in each filter as well as it should be based on time cycle. An operating console shall be provided for each filter to facilitate manual operation of valves.

Back wash water shall be drawn from common channel of filtered water. Air shall be blown from the bottom of filter beds to attain effective backwash. For this purpose blower shall be provided for filter backwash system with provision of 100 percent stand by capacity. Backwash system shall be designed in such a manner that mud balls are not formed in the filter beds. Backwash water storage Pumps etc shall be designed keeping above condition in mind. Provision shall be made for recycling Filter Backwash water.

The filter floor shall provide access to the filter installation and shall permit the observation of the water surface in each filter and to allow maintenance and necessary manual operation of the inlet and washwater outlet penstocks. Hand railing of stainless steel 304 shall be provided around each filter.

The backwash pumps, backwash air blowers and associated plant shall be located in a plant room area at any one end of the filter installation.

The filter building shall be provided with a control room for the plant. This shall be located on the filter floor in such a manner as to provide a clear view over the filter floor. It shall house the central HMI described elsewhere. The filters and associated superstructure shall be of reinforced concrete construction.

The filter power and control panel shall be located in an area accessible to the operator for effective and efficient operation of the plant. Filter washing consoles shall be located on the filter floor overlooking each filter pond.

An overflow shall be provided from the common inlet channel which shall discharge into the backwash water channel.

The outlet of each filter shall be fitted with a means of automatically limiting the flow rate immediately after backwash to a value which will not cause an unacceptable reduction in filtrate quality at the start of the run when the filter is clean. Each filter shall be fitted with a headloss indicator ultrasonic digital type. Each filter shall be fitted with a minimum drain gate valve to allow complete emptying of the filter.

The filters shall be designed for backwash by simultaneous air scour and water wash.

The Contractor shall decide the exact dimensions and layout of the filters, and the design of the filter floors and underdrains based on the design criteria and shall have approval of Employers Representative.

The filter house shall include a Filter annexe to accommodate air blowers/ compressors sets with acoustic enclosures, wash pumps and electrical switchgear, motive water pumps, service water pumps which would be visible from the walkway of the filter house. A travelling gantry crane shall run the full length of the Annexe.

7.30.17 Underdrain System

Filter under drain system comprised of PP/HDPE strainers fitted on filter media support slab. Adequate number of strainer at appropriate spacing shall be provided for uniform distribution of wash water during

back wash and for uniform filtration over entire area of the filter. Strainer approved by Client shall only be used for filter under drain work.

The Contractor shall be responsible for the detailed design of the filter floor and underdrains. The filters shall be designed for backwashing by the simultaneous use of air scour and wash water.

The water used for backwashing the filters should be chlorinated to keep the filter media free from biological growth. The filter media and underdrain system shall be designed to achieve uniform distribution of both filtrate and backwash water and air.

The filter underdrain system shall be of monolithic reinforced concrete slab, or SS plates supported on concrete dwarf walls. The means of collecting filtrate and distributing air shall be by use of nozzles set in the reinforced concrete floor. Polypropylene filter nozzles with fine slots shall be used for collecting filtrate and distributing backwash water and air. A uniform distribution of the nozzles of not less than 45 numbers per square metre shall be employed.

The nozzles shall:

- incorporate separate air and water entrances;
- be set at an exactly uniform level;
- be capable of replacement;
- be designed to avoid ingress of sand
- purge valve

All apertures in filter floors shall be plugged during construction to avoid ingress of debris to the under drainage system. The Contractor shall be responsible for ensuring that all debris in the region of the filter floors is avoided during construction of the floor.

7.30.18 Air Scour Blowers

Air for scouring shall be provided by positive displacement (Roots) blowers. Two blowers shall installed, one on duty and one as standbys in a filter house. An acoustic enclosure will be fitted over each air blower to reduce noise. A ring main will convey the air to the filter under floor plenum. Typically, the air scouring rate shall be up to 50 m/h.

This ‘Roots’ type blower will be capable of delivering oil-free air at the specified output pressure and volume. The horizontal inlet and delivery lines shall be sized so that air velocity does not exceed 25 m/s. Blowers shall have the following components but not limited to

- Inlet silencer and filter
- Non-return valve in delivery branch
- Sluice valves resilent in both inlet and delivery branches
- Pressure relief valve or excess pressure safety device
- Bellows type couplings on inlet and delivery branches.
- Direct Coupling

The air blowers shall be installed at an elevation above outside finished ground level. The speed of the blowers shall not exceed 1000 rpm.

The delivery pipework shall be carried to a height above the maximum possible water level in the filters so that, under all circumstances, it is impossible for water to flow back to the blowers. The delivery pipework and valves shall be sized to limit the air velocity to a maximum of 25 m/s.

An electrically actuated air dump valve and flow meter with local indication shall be installed in the pipework feeding the filters. Each blower shall be fitted with an inlet air silencer and discharge air silencer, pressure relief valve, delivery pressure gauge, delivery isolating valve and non-return valves. The noise emitted from the blower shall not exceed 85 dBA at 1.86 m from the blower. (ISO 10816) The blower unit sizing and design of the blower room with acoustic enclosure shall be made such that the acceptable noise levels are met.

The blower room layout shall incorporate a minimum of 2.0 m clear access around the acoustic enclosure. The height of the room and main door shall permit use of the Electric-hoists to effect removal of each acoustic enclosure outside the building.

The design of acoustic enclosure shall facilitate inspection and ease of access to components of the blowers requiring regular inspection and/or maintenance. The air blower, silencers, pipework and flexible connections shall be welded in accordance with BS 4870 or BS 4871.

7.30.19 Specification for Twin Lobe Type Rotary Air blower

Table 18: Specification for Twin Lobe Type Rotary Air blower

Quantity	Two (One working + One Stand By)
Duty	Providing clean dry and oil free air for backwashing of filters Equipment shall be designed to provide clean, dry. Oil free air at optimum power consumption and least noise level. Twin Lobe type Rotary Air Blower, operating below 1500 RPM is recommended. There should be provision in the design to increase or decrease air out put from the blower to the extent of 20 %.
Type	Twin Lobe Type Rotary air Blower.
Capacity	As per bidder's design
Pressure	As per bidder's design
Speed	1500 RPM or below
Noise level	Below 85 db at a distance of 1.86 M., from blower
Prime Mover	TEFC, horizontal, foot mounted electric motor with class B insulation, IP 55 protection, and suitable for operation on 415 Volts, 50 Hz AC supply. Motor Shall be Confirming to relevant IS Code

Transmission	By set of V belt & Pulleys
Material Of Construction	a) Casing: High grade CI hardened and machined on internal Surfaces b) Lobes: High Grade CI duly machined and dynamically balanced: c) Internal Gears: High Grade CI duly Machined d) Base Frame: Structural Steel Confirming to IS 226
Accessories:	Inlet and outlet Silencers, Pressure gauge, Safety Valve, Vibration Isolation Pads, Air Filter, etc. Safety Guard (covers) for V- belt & pulley
Testing:	Blower to be tested for capacity, pressure, power consumption, noise level and vibration, etc. at vendors shop as per BS 1571. Dynamic Balancing of rotor and shaft shall be as per ISO 1940.

7.30.20 Filter Back wash Pumps

One working and one stand by pump shall be provided for the purpose of backwashing filters. Pumps shall be horizontal centrifugal type. Discharge rate and head of pumps shall be suitable for effective backwashing of filters in minimum amount of time. Pump shall be of approved make and design.

Construction features of pumps shall be as per General specifications for centrifugal pumps. Pumps shall be provided with prime mover operating on 415 V supply.

All the pipes/channels in filtration plant shall be designed to carry 120% of the designed volume.

Scope of Supply

Following will be included in the scope of supply

a. Design, manufacture /procurement, transportation to the site installation testing and commissioning of pumps with all the accessories as described here below;

- Supply cable of suitable length, duly connected to the motor and cable entry to the pump body duly sealed.
- Coupling flange & other fittings.
- Control panel and instrumentation for automatic operation of the pumps. Control panel shall have all the features as described in the specifications

Process Requirement Duty pump will be working as per the availability of water in the tank. Duty Pump shall start and stop automatically as water level in the sump. For start duty pump shall be selected alternately. Control panel shall have arrangement for the following

- Automatic start of duty pump at first high level of water in the sump.
- Automatic stop of working pump/pumps at low level
- Automatic cyclic change of duty and stand by pump
- Manual start from remote switch

- Alarm for low level, first and second high level, seal failure, and other fault conditions with 'Mute' provision
- Manual override switch `

7.30.21 Sump Pumps

The Contractor shall provide a sump pump installation to remove pump gland leakage and drain down water produced during maintenance of the pumps and pipework. The sump pump/s shall be of the submersible type with pipe, valves etc, and the pump shall be complete with hard wired level controls for automatic start/stop. The pump shall be capable of delivering at least 10 cum/hr and shall be supplied complete with discharge pipework to discharge to the site drainage system.

An alarm shall be raised if the level in the sump becomes high.

7.30.22 Backwash Water Handling Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status associated with the backwash water handling system;
- duty pump selection;
- control mode selection;
- annunciate alarms associated with the backwash water handling systems.

7.30.23 Filter Building Lifting and Handling Equipment

The Contractor shall provide a comprehensive system of lifting beams, runways, pulley blocks, trolleys, slings, etc. to permit the removal of pumps, blowers, motors, valves and actuators for maintenance. The Contractor shall provide handling equipment to enable the removal of the aforementioned items from the building and to load it with ease onto a suitable vehicle. The Contractor shall demonstrate to the satisfaction of the Employers Representative the lifting and handling equipment and procedures to be adopted in using it to remove equipment from the filter building.

The electrically operated lifting/handling equipment and any plant provided shall also facilitate the placing and removal of filter media.

7.30.24 Filter Building Ventilation

Forced ventilation equipment shall be provided to give four changes of air per hour in the filter central gallery and plant room area.

7.30.25 Filtered Water Flow Monitoring

The Contractor shall provide a flow monitoring system to measure total flow from the Works. The flow meter shall be mounted in a factory prepared pipe section having an internal diameter equal to the internal diameter of the interconnecting pipework.

The flow meter shall be installed in accordance with the manufacturer's recommendations. The flow meter shall be mounted within a ground chamber. The flow meter shall not be affected in the event of submersion. The flow meter converter unit shall be remote mounted within a control panel. The flow meters shall operate in the range 0 – 15Ml/d.

Water from filtered water channel shall flow by gravity to the Chlorine contact tank in closed conduit/Treated water channel.

7.30.26 Chlorine Contact Tank

A properly designed Chlorine Contact Tank (CCT) shall be provided after the filter. CCT will be RCC water retaining structure. CCT shall be designed to provide minimum 30 minutes Hydraulic retention time. All internal and external surfaces of CCT shall be provided with 20 mm thick smooth cement plaster in 1:3 C:M. Food grade epoxy paint shall be applied on all internal surfaces of the CCT. Suitable number vents shall be provided in the tank for ventilating free chlorine. Internal baffles shall be constructed in CCT for creating back mixing.

7.30.27 Chlorination System: Chlorinator Room and Chlorine Drum Store

The following description of units and requirements shall be provided for Pre and Post chlorination arrangement. The chlorine building will contain the facilities for storage and dosing of chlorine. A chlorinator Room & chlorine container store forming a chlorine building shall be provided at suitable location to facilitate dosing of chlorine for pre and post chlorination in the plant. Both the rooms shall be located such that it facilitates easy handling, loading, and unloading of the containers. Chlorinator Room and Chlorine container Store shall be RCC frame structure.

Each Chlorination system comprise of following shall be provided

a. Two Nos. of Vacuum Type chlorinator (One Working + One Stand By)

b. Two Nos. of Motive Water pumps (One Working + One stand By)

c. Ejector

d. Vaporizer (if required by the design)

e. Connector for duty and auxiliary Chlorine Toner and gas piping

f. Solution Piping and diffusers

g. Chlorine leak detectors

h. Safety equipment

i. All other accessories required for safe operation of the chlorine system

7.30.27.1 Chlorinator Room

Vacuum type chlorinators shall be suitable for dosing chlorine as per design when the plant is operating at rated capacity. Connector for tonners shall have automatic switch over arrangement from duty tonner to auxiliary toners when duty tonner gets emptied. Weighing arrangement for Duty and auxiliary toners shall be provided. Solution piping shall be in HDPE/ PP. Solution piping shall be suitable for dosing at pre and post chlorination locations. Gaseous chlorine pipe should be of copper.

The chlorinator room shall be constructed adjacent to the container room but with no interconnecting door or other form of access i.e. there will be no internal access to the room containing the chlorine container.

Chlorinators and other equipment will be installed in this room. Chlorinators shall be free-standing, floor-mounted, `V' notch type gas chlorinators or an equivalent approved disinfection system and shall have a turn down ratio of 10: 1 over the full range of works operation.

Chlorinator Room shall be suitable for locating two nos. Vacuum type chlorinators and ancillary equipment's. Room shall be provided with appropriate capacity roof extractor for venting out contaminated air. Exhaust fans and electric hooter should be provided both in chlorinator room and in PLC room.

Each chlorinator shall be equipped with a motorised plug positioned to be actuated by a 4 to 20 mA signal proportional to the total raw water flow as measured by the flume at the works inlet.

Each chlorinator shall have dedicated individual piping for gas feed, motive water, chlorine solutions, injectors and diffusers at the point of application

Suitable water line, chlorine gas line, chlorine store line should be provided. Chlorine booster pump should be provided. All gaseous chlorine line should be of copper and chlorine solution line should be of PVC.

Remote vacuum regulators mounted in the container room shall ensure that chlorine gas in the chlorination room is under vacuum.

Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central HMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

Provision for manual setting of the dosing rate shall be built in the system in addition to automatic dosing adjustment and each chlorinator shall be equipped with a 0 to 5 mg/l scale and a manual dose setter over the complete range.

Post chlorination will be at a dose sufficient to leave a residual of at least 1.5 mg/l in the treated water reservoir. The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

7.30.27.2 Chlorinator Booster Pumps

Each set (2 nos) of working chlorinators shall have minimum one duty booster pump. Similarly for each set (2 nos) of standby chlorinators, there shall be minimum one dedicated booster pump. One duty pump shall supply booster water for raw water pre-chlorination and the other duty pump shall supply booster water for post chlorination. The booster pumps shall draw their supply from a suitable chlorinated water source. The pumps shall be located adjacent to the backwash pumps in the filter plant hall.

7.30.27.3 Injectors

Four injectors shall be provided, two serving duty pair/two for standby pair of chlorinators. So both pre and post-chlorination put together 8 nos. of Injectors shall be provided. The injectors shall be located at the point of application. Injectors and booster pumps shall be provided to allow chlorination at the levels and to the dosing points specified taking into account the minimum water level at the suction of the booster pumps, the maximum water level at the dosing points and pressure losses in water and chlorine solution lines.

7.30.27.4 Chlorine Container room

Container room with crane shall be provided for the storage and handling of the chlorine drums. Gas lines from the container room into the chlorinator room shall run in ducts to be sealed after installation and prior to commissioning. Chlorine container store will have walls on three sides up to 1000 mm ht. Floor of Chlorine Container room shall be provided with ironite top finish.

Drum Storage shall be provided for at least 15 days usage at the maximum rate of application.

Drums on line, drums on standby and storage of full and empty drums, shall be stored in the drum room. Drum rollers shall be provided as required to position the duty and stand by drums. Drums not in use shall be stored on concrete cradles one for each tonner.

Provision for electrically operated hoist shall be made for loading and unloading of drums from the lorry as well as for handling of drums in the chlorine store. An overhead single girder electric travelling crane shall be provided in the chlorine drum room for the following functions:

- offloading (and reloading) of drums from trucks;
- transport of drums within the storage area.

The system shall serve the drum store width over the entire length including the loading/unloading area.

The hoist and traverse speeds shall be as follows;

-	Long traverse speed	:	10 m/min
-	Cross traverse speed	:	not more than 10 m/min
-	Slow lifting speed	:	1 m/min
-	High lifting speed	:	10 m/min

The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks. Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 110 volt AC supply.

Two lifting beams shall be provided (a duty and a spare) and one drum weigher to be suspended from the crane hoist. Each duty and standby drum assembly shall be connected to their respective chlorinators via an automatic drum changeover device located within the drum store.

When the pressure in the duty chlorine drums falling to less than 15 psig the automatic changeover device shall operate to isolate the empty drums and to bring the full standby drums on to line.

7.30.27.5 Safety Equipment

One set of safety equipment and emergency repair tool kit shall be provided in chlorinator Room as well as in drum store area. Safety charts and printed operating instruction in bold readable prints shall be paste on walls of Chlorine Drum Store and Chlorinator Room.

Chlorine safety equipment comprising of mask, canister leak detection etc. shall be provided in chlorine room.

Firefighting extinguishers, first aid equipment as per statuary requirement shall have to be provided in chlorine room and in chlorine store.

Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

The chlorination house and chlorine drum room shall have chlorine fume detectors and be force ventilated.

Other safety equipment shall be provided including emergency blowers, resuscitators, breathing apparatus and suits.

Provision for an alkali pit shall be made so as any leaking drum can be dumped into it by lifting and moving it by electrical hoist. A pit and alkali absorption system shall be provided to contain and neutralise chlorine in

the event of a leak. The system shall comprise a pit located in the drum room and accessible by the overhead crane system. The pit shall be provided with load bearing covers which can be easily removed manually in an emergency and shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two 1 tonne nominal capacity chlorine drums. A pump shall be provided in the base of the pit to facilitate emptying.

Special consideration shall be given to any floor drainage system in the drum; adequate traps shall be provided to ensure that chlorine gas cannot escape into other system. All leader tubes carrying cables or pipes out of the building shall be sealed at either ends to prevent any chlorine gas leaking out.

The safety equipment shall include but shall not be limited to:

- two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 200 litre capacity, 140 mm diameter, air cylinders;
- two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air cylinders, control manifold, airline hose and hose winding drum. Two spare cylinders suitable for changeover shall be provided;
- one portable electric motor driven air compressor for recharging air cylinders, complete with quick-release air hose couplings;
- two `instant action' resuscitators.
- four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building. Two emergency showers shall be provided and shall be installed outside on either side of the drum room. Each shower shall be operated automatically by a quick acting hand or foot valve.

Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers. Water for the showers, etc, shall be drawn from the service water supply.

Contractor will have to obtain necessary approvals for storing of Chlorine Drums from Explosive Inspector's office and all other statutory approvals required for handling, storage and use of chlorine gas in pressurized cylinder.

Design and safety features outlined in CPHEEO Manual should be adhered to.

7.30.27.6 Chlorine Leak Detectors

Leak detector with alarm system shall be located in Chlorinator Room as well as in Chlorine Drum Store. Signal from leak detector shall activate exhaust system. Not less than three chlorine gas leak detectors shall be provided each with a single detector cell. At least two sensors shall be located in the drum room and at least one sensor in the chlorination room.

The chlorine leak detectors in the drum room shall be mounted at each end of the drum room. The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 ml/m3. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

- low level 2 ml/m^3
- high level 4 ml/m^3

The low level alarm shall:

- initiate a local audible and visual alarm;
- start the ventilation fans in the drum and chlorination rooms;
- raise an alarm at the local control panel and at the central HMI.

The high level alarm shall:

- initiate local audible and visual alarm;
- initiate an audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings located within the Water Treatment Plant Campus);
- raise an alarm at the local control panel and at the central HMI;
- shut down the chlorination systems;
- stop the drum room and chlorination room extract fans.

The chlorine detectors system shall be provided with a back-up power supply to maintain the units and alarm system in operation for 4 hours in the event of a power failure. The chlorine detectors shall have self-checking circuitry and detector failure. Alarms shall be provided at the local control panel and central HMI. Detector failure alarms shall not be combined with the leak alarms. Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall either be pictorial or provided in Hindi and English.

7.30.27.7 Ventilation System

Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system. Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation. Extract air shall be ducted from low level and discharged at high level.

The ventilation systems shall be designed to provide for general day to day use an air change rate of four per hour and a minimum of twenty changes of air per hour for use in the event that a chlorine leak is detected. Extract fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

Ductwork shall be manufactured from U-PVC extruded sheets or circular sections complying with BS 3757 and BS 3506. Fan controls shall be linked to the gas leak detection system. Hardwired fan controls shall be provided and shall be manually controlled. An override shall be provided to operate the fans as required in the event of a chlorine leak alarm. Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:

- fan off/on;
- fan running/failed indication lights;
- low and high gas leakage indication alarm light.

An override facility shall be provided to permit, under manual supervision only, the ventilation fans to be operated in order to disperse gas after isolation of a gas leak. Indicator lights shall be provided at the entrances to the chlorination room and the drum room to indicate whether the ventilation system running.

7.30.27.8 Chlorine Residual Monitors

Two chlorine residual monitors shall be provided for monitoring the raw water and final treated water downstream of the chlorine injection points.

The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

The sampling pipework complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipework shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample water not passed through the monitor shall be returned to the process.

The residual signals shall be displayed at the local control panel and at the central HMI. High and low chlorine residual levels shall raise alarms at the local control panel and at the central HMI.

7.30.27.9 Chlorination Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status and values associated with the chlorination systems;
- duty pump selection;
- annunciate alarms associated with the chlorination systems;
- operator adjustment of process set points.

The chlorination systems shall operate using a fixed manually/ automated set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point through PLC/SCADA. The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

The duty booster pumps shall be manually started at the control panel. The action of starting the duty booster pump shall start the chlorination process concerned. The operation of the room ventilation and fume detection systems shall be independent of any PLC controls and shall operate in any mode. Cable support systems throughout the chlorine installation shall be constructed of U-PVC.

7.30.27.10 Service Water System

The Contractor shall provide a complete service water system: A covered service water storage tank shall be mounted on the roof of the chemical house. The service water storage tank shall be fed by duty / standby service water pumps located in the filter plant room. The storage tank shall provide at least one hour's storage of service water at average usage rates.

The service water system shall supply water for:

- chemical makeup;

- tank cleaning and flushing;
- diluent flows for coagulants / chemicals;
- emergency showers and eyebaths;
- hose points at the coagulants/chemicals storage area.
- the domestic water system.

All service connections shall be provided with isolation facilities to permit work to be carried out at one point of supply without affecting other users.

An independent power and control panel shall be provided for the service water system. Status annunciation shall be carried out using discrete indicator lights located on the pump starter enclosures.

The duty pump shall be controlled by level probes located in the storage tank.

The following alarms shall be provided at the control panel and at the central HMI.

- duty pump failure;
- system failure (i.e. both pumps failed or a similar occurrence which prevents the system from working);
- storage tank high level.

7.30.28 WTP Wastewater Recovery & Recycle System

A wastewater recovery system shall be provided to reduce the water loss from the treatment process and thereby recover some quantity of water and also to handle the sludge coming out from the clarifiers / tube settlers. The sludge shall be dewatered and disposed safely to an identified secure landfill site in consultation with local municipal body and cited within a distance not more than 20km.

The Waste water recovery & sludge treatment process shall primarily comprise of:

- Filter Backwash wastewater storage tank with mixing and pumping arrangement
- Recovered water storage and recycling pumps
- thickened sludge sump;
- centrifuge feed pumps;
- polyelectrolyte feeding pumps;
- mechanical sludge dewatering;
- Filtrate/centrate collection tank with pumps.;
- sludge storage with periodic disposal to landfill.

The wastewater from the backwash from filters shall be collected in a storage tank with minimum capacity to hold waste water generated during two backwash.

The clarfied water/supernatant shall be collected in a sump and pumped back to inlet chamber of WTP

Settled sludge from Clariflocculators/ Tube settlers shall be collected in a sludge holding cum thickener tank.

Overflow from this tank shall be taken to filter backwash wastewater storage tank, while the thickened sludge shall be collected in a sump and pumped to sludge dewatering machines along with chemical feeds if any.

Centrate/filtrate shall be collected in a sump and shall be pumped to Backwash wastewater storage tank or be used for gardening within the premises or discharged in to the drain.

Dewatered sludge cake should have dry solids concentration of minimum 20%. This shall be stored in a covered shed with concrete platform. (minimum storage facility shall be for 15 days). The stored sludge shall be periodically disposed off, as guided by Engineer in charge, in consultation with local municipal body, to a disposal site located within 20 Kms from the WTP site.

Provision be made that if required, the filter backwash wastewater and clariflocculator waste sludge can be directly be discharged in to the drain.

Provision shall be provided throughout the installation to clear sludge blockage without the removal of pipework sections.

7.30.28.1 Dewatering System Feed Pumps

The Dewatering system feed pumps shall be fixed speed positive displacement pumps. Each pump shall be rated to pump in 16 hours the volume of thickened sludge to be dewatered by Dewatering System during the period of highest raw water turbidity.

7.30.28.2 Polyelectrolyte Make up and Dosing Pumps

Two metering pumps(1 Duty and 1 Standby pumps) and all associated polyelectrolyte make facilities, pipework and valves etc. shall be provided to dose polyelectrolyte from a polyelectrolyte storage tank into the thickener feed line at a rate of up to 5 kg per tonne of dry solids. Each dosing pump shall be dedicated to a thickener feed pump.

The metering pumps shall be of the diaphragm type driven by a fixed speed motor with manual stroke adjustment.

The maximum stroking speed shall be 100 rpm with a 10 to 1 turn down and an accuracy of ± 3% over the operating range.

The metering pump shall be selected as duty along with its corresponding thickener feed pump. The dosing pump shall start and stop simultaneously with the associated duty thickener feed pump.

7.30.28.3 Mechanical Sludge Dewatering System

It shall be located close to sludge thickener unit and shall consist of

- A thickened sludge storage tank with provision of constant stirring to keep solids in suspension. The capacity of this tank should be such as to permit 16 hour operation of dewatering unit
- Pumps to lift sludge to dewatering machine at required pressure
- Mechanical sludge dewatering machine including chemical addition system (storage and feeding system)
- Dewatered sludge collection and transport system

- Decanted water storage and pumping arrangement (either to put water in recovered water tank or for use in horticulture within WTP premised)
- The system hall be placed on a well covered platform
- For mechanical Dewatering, chemical feeding system and all pumps and accessories 100% standby capacities shall be provided.

The Dewatering System with 100% standby capacity having sufficient capacity to dewater during 16 hours of operation shall be provided.

The Dewatering System shall produce a dewatered sludge cake of no less than 20% dried solids. At least 98% of the solids shall be in the dewatered cake and less than 2% of the solids shall be in the centrate/filtrate

Operation of each dewatering unit and its associated dedicated sludge feed pumps, polyelectrolyte dosing system, and flushing system and other plant shall be automatic once the start-up procedure has been initiated by the operator.

7.30.28.4 Recovered water storage tank

Recovered water from filter backwash and clarifier sludge shall be collected in sump made of RCC. The tank capacity shall be so designed as to enable recycling of recovered water at uniform rate.

7.30.28.5 Sludge Storage Shed

Dewatered Sludge storage shed of 15 days capacity shall be constructed within the plant. Dewatered Sludge shall be stored on a platform with cemented floor and at least 30 cms above GL. The platform shall be provided with shed extending 60 cms beyond platform on all sides. Minimum height of shed should be 4m. Sloped approaches may be provided on all sides for proper loading and unloading of sludge. The floor shall be sloped in such a manner that filtrate, if any, from dewatered cakes may be collected in channels and discharged in to the channel on two sides of the platform.

7.30.28.6 Water and Sludge Sampling

The Contractor shall provide a suitable drained bench containing two clarity bowls complete with all interconnecting pipework, automatic sampling pumps and drainage facilities for drawing samples from:

- raw water at the inlet chamber;
- Clearwater water reservoir outlet.

The bench shall be sited by the Contractor in the onsite laboratory.

In addition, a further sample bench shall be provided and installed by the Contractor in the laboratory. Sampling equipment shall be provided to deliver continuous samples of the following to the aforementioned bench:

- raw water;
- raw water at the inlet;
- clarified water from each clarifier;
- filtered water from each filter**;**

- water from the clear water reservoir inlet;
- supernatant from each sludge thickener;
- centrate/filtrate from Dewatering System.
- Clarifier sludge
- Thickened sludge
- Dewatered sludge

The sampling arrangement shall include all interconnecting pipework, automatic sampling pumps and taps, adequate sink and drainage.

Convenient means shall be provided to obtain samples manually from each clarified water outlet, each tube settler outlet, each clarifier sludge outlet, each filter outlet, each filter backwash water outlet, treated water reservoir inlet, each thickener supernatant outlet, each thickener sludge outlet and each dewatering unit outlet.

Sample cocks shall be provided locally at both the filtered water holding tank outlet and the thickener feed pump outlet.

7.30.29 Sludge Treatment and Disposal Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status and values associated with the sludge treatment systems;
- duty pump selection;
- annunciate alarms associated with the sludge treatment systems;
- all necessary controls for Dewatering System installation.
- The centrifuge manufacturers proprietary control panel/s may be provided in addition to the above providing the requirements for Dewatering System status and alarm annunciation are fulfilled locally and at the central HMI.

7.30.30 List of Equipments/Instruments for Automatic operation of Water Treatment Plant

- Filter inlet works
- Filter outlet valves
- Backwash wash inlet valves
- Backwash water outlet valves
- Filter backwash water pumps (to be connected with level/operated switches on backwash water storage tanks)
- Clarifier desludging valves

7.30.31 Intercom System

An intercom system shall be provided between the following points within the treatment plant:

- control room
- The pump and compressor room with the adjacent main distribution panel room
- the laboratory
- the chemical house (chlorinator room, point close to the chlorine storage area)
- the filter operation gallery
- the pipe gallery of the filter house
- reception, office, store Room, MCC Room
- Administrative building, laboratory.

7.30.32 Laboratory and sampling system

The quality of the water entering, passing and leaving the treatment plant shall be monitored via HDPE sampling pipes DN 25 from the following points leading to the laboratory:

- raw water pipe at the inlet chamber (raw water)
- outlet channel of the clariflocculators (clarified water)
- end of the filtered water channel (filtered water of all filters)
- outlet of the chlorination chamber (treated water)
- pressure pipe of the clear water pumping station

The sampling pipes lead from the sampling point to small sampling pumps installed at a low area of the pipe gallery of the filters. From there, pressure pipes lead to the laboratory to the outlet points.

Sampling at individual units shall be made with the help of a sampling bottle in the case of open reservoirs or channels and from taps. Each sampling point shall be provided with an outlet convenient for the collection of samples for laboratory testing and for the connection of a portable turbidity meter.

The laboratory shall be housed in administrative building. It shall have the equipment, storage space and chemicals for the following chemical and bacteriological routine analyses:

- temperature
- turbidity
- suspended solids
- residual chlorine
- pH

The testing methods shall be as simple as possible (colorimeter, comparator, pre-defined test kits, etc.) and the equipment as robust as possible. The methods shall be described in a test manual.

The laboratory shall have 1.2 m high working granite platforms with sinks. The sampling pipes shall end at one of the sink. The taps shall be clearly labelled with the type and provenience of the water. A portable direct reading turbidity meter shall be provided for the measuring of the turbidity at the individual measuring points.

All the sampling points shall end in clarity Bowls in laboratory for easy collection and analysis.

7.30.32.1 LABORATORY EQUIPMENTS

Following minimum laboratory instruments/equipment shall be provided but shall not be limited to:

Sl. No.	Equipment	Minimum Quantity to be provided
1.	pH meter	2
2.	NepheloTurbity Meter	2
3.	Chlorine analyser (comparator)	1
4.	B.O.D. Incubator	1
5.	Pipettes, burettes and other glass ware	As required
6.	Incubator	2
7.	Autoclave	1
8.	Water Bath (serological)	1
9.	Binocular Microscope	1
10.	Electric balance	1
11.	Jar Test apparatus	1
12.	Magnetic Stirrer	1
13.	Distilled Water Plant	1
14.	Sampling Bottles (Reagent Bottles of 250 ml Capacity)	24
15.	Electric Oven	1
16.	Wire Baskets	6
17.	Suction flask (1litre capacity)	1
18.	All types of laboratory glassware, accessories and other consumables and regents for minimum one year requirement	One Lot
19.	Sieve Analysis set with shaker	1

Sl. No.	Equipment	Minimum Quantity to be provided
20.	Analytical balance	1
21.	Constant voltage transformer	1
22.	Vacuum cleaner	1
23.	Refrigerator (365 ltr.)	1
24.	Colorimeter including UV and infrared range for chemical analysis.	1

7.30.33 Brief Description of Instrumentation

Providing following listed monitoring and control instrumentation is minimum requirement under this contract

Sr. No	Instrument	Type	Location
1	Water Flow Meter	Magnetic/ Ultra sonic type	Inlet line to plant
2	Water Flow Meter	Magnetic/ Ultra sonic type	Clear water rising main after Clear Water Pumps
3	Level sensor & transmitter for filter beds	Ultra Sonic / Capacitance Type	One in each Filter bed
4	Level sensor Controller for water tanks	Float / Capacitance type	Clear Water Sump
5	Residual Chlorine Analyzer	On line type	Clear water rising main
6	Turbidity Analyzer	On line type	Raw water Line
7	Turbidity Analyzer	On line type	Clarifier water out let
8	Turbidity Analyzer	On line type	Filtered water out let
9	Level indicator		Coagulant/chemical Solution tanks
10	Pressure Gauges	Bourdon type	On all pump and air blower discharge lines

A PLC system shall be provided to monitor and control the operation of the plant. This system shall be suitable for real time display of status of plant units, on off position of various pumps and equipment open

close position of valves, etc. monitoring parameters and shall be suitable for programming the auto operation of the filters as per the requirement. PLC system shall be provided with 100 % redundancy, colour monitor, and dedicated UPS and a printer. Contractor will have to submit details of the system for approval of client before finalizing the design. Providing power supply, signal cables etc whatsoever required for instrumentation work is included in the scope of contract.

7.30.34 Brief Description and specification for Interconnecting Piping

Supplying, laying jointing and testing of interconnecting piping and valves with all accessories like support brackets pipe racks etc. are included in the contractor's scope of work. All the piping shall be carried out as per the specifications given in this tender document and following the relevant IS codes, using best quality material. Tenderers are advised to make their own assessment of the requirement of Pipes Valves, fittings. Jointing material, gaskets, nuts bolts, and pipe supports etc. whatsoever is required for successful completion of the job as per the specifications.

Pipeline shall be design taking following into consideration

Sr. No	Pipe details	MOC
1	Pipe from Raw Water Take off point to Inlet Chamber	DI
2	All interconnecting piping between plant units	DI
3	Filter Back wash water line	DI
4	Scour Air Line	MS
5	Sludge and Filter back wash water lines	DI
6	Chemical dosing line	HDPE/ PP
7	Chlorine solution line	HDPE/PP
8	Clear Water pipes & fittings within pump house	DI

All gravity flow line shall be design for fluid velocity of 0.6 to 1 m/sec. All Pressure lines to be designed for Fluid velocity of 1.5 m/sec. Scour air pipeline shall be designed for 25 m/sec fluid velocity. All fitting in HDPE/ PP line shall be moulded/electrofusion joints.

7.31 PARTICULAR TECHNICAL REQUIREMENTS – CIVIL WORKS

This section specifies the technical requirements pertaining to Civil works. The General Civil requirements and standard specifications included in the tender shall be read in conjunction with these requirements.

7.31.1 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the requirements. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both directions right angle to each other for walls and rafts.

Suitable gap at the location of expansion joints placed at a suitable interval not more than 30m shall be provided in walls, floors and roof slabs of all structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided as per convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height. Approved PVC water-stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

Expansion joints for non-liquid retaining structures shall be provided as per IS 3414.

7.31.2 Partly/Fully Underground Liquid Retaining Structures- Basis for Design

All underground or partly underground liquid containing structures shall be designed for the following conditions:

i. liquid depth up to full height of wall and free board: no relief due to lateral soil pressure from outside to be considered;

ii. Reservoir empty (i.e. no liquid or any material inside the storage area): full lateral earth pressure at rest due to surrounding saturated soil and surcharge pressure as applicable, shall be considered;

iii. partition wall between dry sump and wet sump to be designed for full liquid depth up to full height of wall;

iv. partition wall between two compartments to be designed as one compartment empty and other full;

v. Structures shall be designed for uplift in empty conditions considering the depth of the highest water table recorded in the area.

vi. walls shall be designed under operating conditions to resist earthquake forces developed due to mobilization of earth and dynamic liquid loads;

vii. Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures on the base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.

7.31.3 Foundations

i. The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS: 1904.

ii. Care shall be taken to avoid the interference of the foundations or any other component of the new building with the foundations of adjacent buildings or structure. Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. The Employer's Representative shall accept no extra claims for such adjustments.

iii. Base raft for underground structure shall be designed for uplift forces that are likely to be developed.

iv. Where there is level difference between the natural/ existing ground level and the foundations of structure or floor slabs, this difference shall be filled up in the following ways:

- In case of non-liquid retaining structures the natural top soil shall be removed till a firm stratum is reached (minimum depth of soil removed shall be 500 mm.) and the level difference shall be made up by compacted backfill as per specifications. However, the thickness of each layer of the backfill shall not exceed 150 mm. The area of backfilling for floor slabs shall be confined to prevent soil from slipping out during compaction. The safe bearing capacity of this well compacted backfilled soil for design calculations shall not exceed 100 KN/m^2.
- In case of liquid retaining structures, the natural top soil shall be removed as described above and the level difference shall be made up with Plain Cement Concrete (1:5:10)

7.31.4 Requirements for Reinforced and Plain Concrete Works (Structures)

The following are the design requirements for all reinforced or plain concrete structures:

a. All blinding and leveling concrete shall be a minimum 100 mm thick with minimum concrete M10 grade.

b. All structural reinforced concrete other than for water retaining structures shall at least be of M25 grade with 20 mm size downgraded coarse aggregates, for all structural members.

c. The minimum grade of concrete for water retaining structures shall be M30 having minimum cement content of 320 kg/m3 with 20 mm size downgraded coarse aggregates.

d. The minimum clear cover to all reinforcement including stirrups and links shall be 40 mm for all water retaining structures including the bottom of roof. For other structures the minimum clear cover shall be as specified in IS: 456.

e. Any structure or pipeline crossing below roads shall be designed for a minimum of Class A of IRC loading.

f. The bridges and supporting structure (for clarifiers, pipeline crossing river, etc.) shall be designed to safely withstand the loadings such as loads and torque transmitted through scrapper blades, motor, water force in the river, etc. depending on the arrangement offered besides other loads.

g. All pipes and conduits laid below the structural plinth, road works, river bed, nallah crossing, etc. shall be embedded in reinforced concrete of minimum grade M25 having minimum 300 mm thick concrete cover all around.

h. Approved quality water proofing compound (chloride free) shall be added during concreting of all liquid containing structure, in the proportion specified by manufacturer.

i. For walls of liquid retaining structures, the following shall be considered.

- Minimum reinforcement shall be as per IS: 3370 part -2.
- Maximum length of panel to be concreted considering partial construction joints shall be 7.5 m. The adjacent panels shall be poured with a minimum time gap of 4 days. Height of pour shall not exceed 2 m.

j. The following minimum thickness shall be used for different reinforced concrete members, irrespective of design thickness:

i.	Walls for liquid retaining structures	:	200 mm
ii.	Roof slabs for liquid retaining structures	:	150 mm
iii.	Bottom slabs for liquid retaining structures	:	200 mm
iv.	Floor slabs including roof slabs, walkways, canopy slabs	:	150 mm
v.	Walls of cables / pipe trenches, underground pits etc	:	125 mm
vi.	Column footings	:	300 mm
vii.	Parapets, Chajja	:	100 mm
viii.	Precast trench cover	:	75 mm

7.31.5 Requirements for Building Works

Unless otherwise specified, all the building works shall generally comply with the following

a. All buildings shall have Reinforced Concrete framework.

b. 75 mm thick RCC Damp Proofing Course in M15 shall be provided to all building walls.

c. Anti-termite treatment as per IS: 6313 part-III – 1971 with injection of chloropyrious emulsifiable concrete (1%) timber care ground treatment chemically emulsion 1:3 and creating a chemical barrier under and around the column pits, wall trenches, basement excavation, top surface of plinth filling, junction of wall and floor along the external perimeter of building, expansion joints, surrounding of pipes and conduits etc.

d. All external walls shall be in 230 mm thick brick masonry built in cement mortar in (1:4). Transoms and mullions shall be of 115 mm x 230 mm size of cement concrete in M15 with four numbers 6 mm bars and 6 mm links at 150 mm c/c shall be provided to form panels not exceeding 3500 mm x 3500 mm in size.

e. All internal partition walls except for toilets shall be in 230 mm thick brick masonry built in cement mortar 1:4 with transoms and mullions as stated above. Toilet partition walls shall be in 115 mm thick brick masonry built in cement mortar 1:4 and shall have transoms and mullions as stated above to form panels not exceeding 1200 mm x 1200 mm size.

f. All internal masonry surfaces shall be finished with 12 mm thick smooth faced cement plaster in cement mortar (1:4).

g. All external masonry surfaces shall be plastered in two coats with sand faced cement plaster in cement mortar (1:4) and shall have total thickness of 20 mm. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.

h. Bathroom/ W.C. floor slab shall be sunk and filled with brickbat coba (broken bricks set in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company. The finished floor level in Bathroom / W.C. areas shall be normally 12 mm below the finished floor level on the outer side.

The toilet facilities shall include at least:

i. 1 No. Water closet with white porcelain EWC/Orissa pan minimum 580 mm long with PVC flushing cistern of 10 liters capacity.

ii. 1 No. Urinal of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a kota stone partition of size 680 mm x 300 mm shall be provided outside toilet.

iii. 1 No. Washbasin of size 510 mm x 400 mm in white Porcelain with inlet, outlet with bottle trap.

iv. 1 No. Mirror of size 400 mm x 600 mm PVC moulding wall mounted type fitted over washbasins.

v. 1 No. Plastic liquid soap bottles

vi. 1 No. Chromium plated brass towel rails minimum 750 mm long.

vii. All stopcocks, valves and pillar cocks shall be of chromium-plated brass, heavy duty.

viii. All fittings such as `P' or `S' traps, floor traps, pipes, down-take pipes etc.

ix. The sewage from toilet blocks shall be led to a septic tank with soak pit till the sewerage system is developed and later connection to the sewer line as directed by the Employer. The Contractor, at a suitable location, shall provide a septic tank having appropriate capacity, as per specifications.

i. Wherever specified, staircases shall be finished with 25 mm thick Kota Stone treads and 20 mm thick Kota Stone skirting. The rise of stairs shall not exceed 170 mm and minimum width of the tread shall not be less than 275 mm. All steps shall have 20 mm nosing. R.C.C. stairways shall be provided to permit access between different levels within buildings. All roof tops and tops of overhead tanks shall be made accessible with ladder provision. Vertical ladders fitted with landing point extensions will be permitted where considered appropriate by the Employer's Representative to access areas not frequently visited.

j. All floor cutouts and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and G.I. chequered plates of adequate thickness in indoor

areas. All uncovered openings shall be protected with G.I. hand railing fixed with two rails. Top railing and vertical of the G.I hand railing shall be 32 mm dia. G. I. Pipe of Class-A. The lower railing shall be 25 mm dia. G.I. pipe of Class A.

k. All staircases shall be provided with SS304 railing with PVC cover or wooden handrail.

l. The reinforced concrete roofs shall be made waterproof by application of approved cement/ lime based waterproofing treatment. The finished roof surface shall have adequate slope to drain quickly the rainwater to R.W down-take points.

m. For roofing drainage, PVC rainwater down-takes with khurra and door bend with grating at top shall be provided. For roof areas up to 40 m^2. minimum two nos. 100 mm diameter down-take pipes shall be provided. For every additional area of 40 m^2 or part thereof, at least one no. 100 mm dia. down take pipe shall be provided. The RW pipes shall be concealed.

n. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rainwater.

o. Building plinth shall be minimum 450 mm above average finished ground level around building and shall not be less than plinth level of existing buildings.

p. All buildings shall have a minimum 1.0 m wide, 100 mm thick plinth protection paving in M15 grade concrete finished with stone slabs/ tiles. All plinth protection shall be supported on well-compacted stratum.

q. All concrete channels and ducts used for conveying liquid shall have smooth finish from inside. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with G.I. hand railings.

r. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of the Factory Act.

s. All rooms in the treatment plant buildings shall be provided with appropriate signboards indicating the function of the rooms involved.

t. Wherever equipment and machinery is required to be moved for inspection, servicing, replacement etc., suitable movable gantry of required capacity shall be provided.

u. The design of buildings shall reflect the climatic conditions existing on site and it shall as far as possible permit the entry of natural light.

v. Emergency exit doorways shall be provided from all buildings in order to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.

w. Toilet blocks in process building shall be provided with two drinking water taps of 12 mm size and sink with appropriate drainage.

x. All chequered Plates shall be hot dip galvanized.

y. All types of opening such as doors, windows and ventilators shall be minimum 25% of the floor area.

z. Glass shall be minimum 5 mm thick, pin headed or opaque.

7.31.6 Concrete Reinforcement

All major structures, buildings, pump Station, water treatment plant, Electrical sub stations, canal crossing structures, thrust blocks, pillars and all water retaining structures including all other structures in the Contract will use Fe500 of approved make/manufacturer for concrete reinforcement.

7.31.7 Requirements at Water Treatment Plant

The buildings to be constructed other than required for WTP are listed below:-

1. Equipment Store room 1 no.
2. Security cabin 1 no.

7.31.8 Administration and Control Building

The control building shall have the following rooms at the ground floor.

a) Administration and Control Building of plinth area not less than 200 m^2 shall be constructed comprising of one large hall (5m x 10m approx.) for administrative staff and at least four rooms for officers and senior plant manager. Administration and Control Building shall be provided with all civic amenities. All areas in the Block under routine occupation shall be suitably Air-cooled. Minimum floor to ceiling height of these areas shall be 3.5 m.

b) Main control room for the whole treatment plant with control panel (not less than 40 m^2). Minimum floor to ceiling height of these shall be 3.5 m.

c) Staff room with toilets (total size not less than 15 m^2). Minimum floor to ceiling height of these areas shall be 3.5 m.

d) Canteen Room of minimum 20 m^2 area

e) Store Room of minimum 20 m^2 area

f) Lobby, corridors, staircase

The first floor of control building shall have:

a) Laboratory for the chemical and bacteriological analyses of the raw and Clear water (not less than 60 m^2);

b) Staff toilets (Indian), visitors' toilets (Indian and western, urinal) (not less than 15 m^2);

c) Outdoor observation platforms and access to the units of the plant

d) Corridors, staircase

The roof terrace shall be accessible for inspection via staircase. Finishing and other requirements are as in Requirement of Administration and Control building.

7.31.9 Buildings and site development Works

Table 19: Requirements for building units other than Administration and Control building, Officers and Staff Quarters

Sr. No.	Particulars	Specification to be adopted			
1.	Type of Structure	RCC framed Structure			
2.	Damp Proofing Course	75 mm thick Reinforced Cement Concrete in M15			
3.	Exterior Walls				
(a)	Below G. L.	Stone masonry in CM 1:4 up to G. L.			
(b)	Above G. L.	Brick Masonry Wall in C. M. 1:4 min 230mm thick.			
4.	Interior Walls				
(a)	Below G. L.	Stone masonry up to G. L.			
(b)	Above G. L.	Brick Masonry Wall in C. M. 1:4 min 230mm thick.			
5.	Partition Walls	Half Brick in C. M. 1:4 reinforced properly			
6.	Roofing	RCC / For flat roofs treatment shall be provided with brick bat coba and finishing coat of 25 mm thickness in CM 1:4 with Water Proofing Treatment			
7.	Interior Plaster	Cement Mortar 1:4, 12 mm thick			
8.	Exterior Finish	Combination of Grit Wash and Dholpur or Karauli Stone facing in front face and water proofing cement paint on side and back.			
9.	Interior Finish	Floor	Wall Finish	Doors	
	Unit			Frame	Shutter
	a) Bulk Chemical Storage building	CCH	WW	PSDF and RS	DDS and RS
	b) Staff Toilet	KS	Ceramic Tiles upto LL	PVC	PVC
	c) Lobby	Kota stone	AE	AL	ALG

Sr. No.	Particulars	Specification to be adopted			
	d) Staircase	KS	WW	-	
	e) Garage	CC	WW	RS	
	f) Chlorinator room	TPT	WW	RS	
	g) Chlorination control room	TPT	WW	PSDF	DDS
	h) Clarifier control room	TPT	WW	PSDF	DDS
	i) Coagulant dosing room	TPT	WW	PSDF	DDS
	j) Filter control gallery	TPT	DT	PSDF	DDS
	k) Backwash pumps and compressor room with sump	CCH	DT	PSDF RS	DDS RS
	l) Workshop	CCH	WW	RS	
	m) Security cabin	TPT	WW	PSDF	DDS
	n) Filter Pipe gallery	CC Flooring	DT	PSDF	DDS
	o) Office	TPT	AE	PSDF	FD
	p) Archive	TPT	WW	PSDF	FD
	q) Laboratory	KS	WW	PSDF	FD
10.	Sanitary				
	W. C.	Indian type Orissa Pan Size 540mm			
	Urinals	Flat Back size 610x400x80 with 25 mm G. I. Waste pipe			
	Flushing Cistern	Low Level 10 liter Capacity, PVC			
	Wash Basin	Flat Back 550x400 mm			

CCH – Cement Concrete with Hardener, KS – Kota stone, CC – Cement concrete, TPT – Terrazzo precast tiles, WW – White wash, AE – Acrylic Enamel, DT – Distemper, PSDF – Pressed steel door frame, RS – Rolled shutter, PVC – Polyvinyl chloride, AL – Aluminium,

Table 20: Requirement of Administration and Control building

Sr. No.	Type of Building	Administration and Control building
	Brief Specifications	
1	Structure	RC framed Structure
2	Masonary in foundation and plinth	RR stone masonry in CM 1:4 Or minimum 230 thick Brick Masonry in CM 1:4
3	Damp proof course	RCC M15 with water Proofing Compound
4	Masonry in Superstructure	Brick Masonary in CM 1:4 230mm thick minimum for external walls and 115mm for Internal partition walls
5	Lintels sun-shades etc	R.C.C. lintels and sun shades
6	Roofing Treatment	Brick bat coba with water proofing compound min. average 75mm thick.
7	Internal Plaster	12mm CM 1:4 for walls, 12 mm the CM 1:4 for ceiling
8	Exterior Finish	Combination of Grit Wash and Dholpur or Karauli Stone facing in front face and water proofing cement paint on side and back
9	Flooring	
a	Beneath floor	C.C. 1:3:6 base concrete
b	Finish	Terrazzo Precast (Grey cement) tiles
10	Skirting and dados	10 cm. Height to match flooring
11	Windows (frame, panels, wire gauging, safety bars)	Frame - Assam teak Inner Shutters - Wired gauge Teak Wood frame Outer Shutter - Glazed panel teak wood shutter

Sr. No.	Type of Building	Administration and Control building
12	Doors (Frames and shutter)	Frame - Assam teak section 150 x 75 mm Shutter - Fully paneled teak wood door as per specifications and approved drawing
13	White/ Colour/Cement lime/ Decorative Finish	Oil bound Distemper
14	Painting of doors, Windows and walls	Synthetic enamel paint
15	Electrification (type of wiring, fittings and fixture)	PVC Conduit wiring as per drawing and specifications
16	Sanitary and Water Supply	
	(I) Indian WC	In servant quarters and in common toilets
	(ii) European WC	In attach toilets with room
	(A) Wash Basins	In every toilets and in lounge
	(iv) Sinks	Steel sink
	(v) Other accessories	As per approved drawing
17	Other Specification	PVC frames and shutters in Bath rooms/Toilets
18	Special fitting and fixture	
a	Fans	In every Room
b	Tube light	In every Room
c	Exhaust fans	Kitchen / Bathroom
d	Coolers	In every Room

7.31.10 Clear Water Reservoir, Sump

One clear water reservoir of 1670 m^3 capacity is to be constructed with two equal compartments of 835m^3 each. The two compartments shall receive water from inlet pipe of WTP. The inlet pipe will split near CWR and shall connect to two compartments with separate inlet pipes and separate valves. The clear water reservoir shall have total live storage of 1670 m^3 above the water level required for pump with vortex free

suction. The CWR roof shall be kept at least 1.00 meter above general ground level. Ventilators shall be provided in CWR roof at suitable location and all openings of CWR shall be kept covered. The ventilators shall be provided with MS grill and wire gauge net to prevent dust entering the clear water reservoirs. The live storage depth shall not exceed 5 meters.

7.31.11 Clear Water Pump Station

The clear water pump station building is to be constructed along with Electrical outdoor switchyard. The Pump Station shall have Pump Station, Duty room, Maintenance bay, Toilet block, PLC Control Room etc.

Table 21: The general requirement of pump Station buildings shall be as follows:

Sr. No	PARTICULARS	SPECIFICATIONS
a)	Type of Structure	RCC frame Structure
b)	Plinth Level	Minimum 0.60 meters above finished ground level
c)	Minimum Height of building above finished floor Levels	As per design
d)	Retaining Walls	RCC
e)	External walls Below Ground Level	RR stone masonry in Cement Sand mortar 1:4
f)	External walls above Ground Level	Brick masonry 230 mm thick in Cement Sand mortar 1:4
g)	Internal load bearing Walls and partition wall around electrical/ battery rooms	Full Brick 230 mm in Cement Sand mortar 1:4
h)	Partition walls	Half Brick masonry in Cement Sand mortar 1:4
i)	Earth Filling for Reclamation of additional Land	With suitable earth with compacted to 95% modified proctor density
j)	Area for PLC Control Room with AC	40 m^2 having partitions with aluminum framed glazed panel partitions of height up to lintel level
k)	Area for duty room	70 m^2
l)	External finish	Either of water proofing cement paint, sand face plaster, Dholpur/Karauli stone facing as per approved architectural plan
m)	Plaster	
n)	Interior Plaster	12 mm thick in Cement Sand mortar 1:4

Sr. No	PARTICULARS	SPECIFICATIONS
o)	Plaster on external Walls	20 mm thick in Cement Sand mortar 1:4, two coats
p)	Ceiling Plaster	8 mm thick in Cement Sand mortar 1:4
q)	Toilet	Ceramic tiles up to lintel level and plaster 20 mm thick in Cement Sand mortar 1:4 above
r)	False Ceiling	Required in PLC control room
s)	Flooring	
t)	Pump/motor Room	Floor Hardener topping with CC base
u)	Switchgear Room	Kota stone with rubber mat
v)	Battery room and Battery charger Room	Acid resistant tiles for flooring and dado, Sink and eye wash
w)	Operator office space/ duty room/ stairs / office space/toilets and other areas	Kota stone
x)	PLC control room	Anti-static PVC flooring with CC flooring base
y)	Walk ways	GMS Chequered plates
z)	Corridors and stairs	Kota stone
aa)	Painting	
bb)	Outer building area	Cement based paint
cc)	Inner areas of pump/motor room, office area and lobbies	Dry distemper
dd)	PLC Control room	Acrylic Plastic Emulsion Paint
ee)	Battery room	Acid resistant paint
ff)	Doors	
gg)	PLC Control room	Glass paneled Aluminum Double door shutters with aluminum frame and single panel hinged shutters with door closures. The first gate shall be provided with air curtain of appropriate design to ensure dust proofing.

Sr. No	PARTICULARS	SPECIFICATIONS
hh)	Main Entrance Doors	Glass paneled Aluminum door shutters with aluminum frame and double panel hinged shutters with door closures.
ii)	Switchgear room/ Battery room	2 hour Fire rated door-HMPS(hollow metal pressed steel)
jj)	Toilet and other areas	Pressed steel frame with 40mm thick flush doors shutter
kk)	Windows	
ll)	On Outer Front Walls and other windows opening in main entrances	Glass paneled Aluminum shutters with aluminum frame and double panel shutters. (All windows in PLC room will be fixed without shutters of same specifications)
mm)	Other Windows	Steel section window with wire gauge and safety grill
nn)	Cooling Arrangement	
oo)	Entrance lobby	Fans
pp)	Office rooms and duty room	Fans and Coolers
qq)	Pump Station	Air washer
rr)	PLC Control room	Fan and air-conditioners to maintain 24°C temperature throughout the year
ss)	Drinking water arrangements	Taping to be taken from the general water Chlorination system installed for the WTP campus supply.
tt)	Treatment and cooling	Water cooler 40 liter per Hour and storage capacity 80 liters with Zero –B, to be installed

7.31.12 Requirements for Other Area Development Works at Treatment Plant Campus

The campus area of treatment plant is to be developed which includes landscaping, construction of boundary wall all around the campus, providing interior roads, piping and infrastructure for drinking water, electrification of campus area, providing drainage system, providing gates, development of gardens, plantation of trees etc.

7.31.13 Preparatory Works

The Contractor shall undertake the following works:

i) Approval of architecture, design and drawing of civil structures

ii) Approval of developmental plans and landscaping

iii) Approval of design and drawing of quarters and recreation facilities

iv) Drainage plans and designs

v) Electrification of campus area

vi) Pipe and piping work for potable water in campus area

vii) Other designs / plans required for campus area development

7.31.14 Boundary Wall and Gates

Construction of Boundary wall (average height 1.8 meters above ground and wire fencing of 0.6 meters) all along the periphery of the acquired land and providing and installation of gates and Gate lights, complete in all respect. The boundary wall shall be made in RR stone masonry in CM 1:4 and shall be pointed in CM 1:4. The top of wall shall be provided with 75 mm thick RCC coping. The section of the boundary wall & design of gates shall be got approved from the Employer's Representative.

7.31.15 Horticulture and Landscaping

Horticulture and Landscaping shall be done according to the topography of the area and should be planned so as to make the campus a focal point. The open areas leaving expansion requirements must either be covered by tree plantation or must be suitably grassed. Shadow trees must be planted at a maximum distance of 15 m c/c along the periphery of the campus area and along the roads. The campus must be provided with gardens, with seasonal flowerbeds and decorative plants.

In case where unsuitable soil is met with, it shall be either removed or replaced or it shall be covered over to a thickness decided by Employer's Representative with good earth.

The concrete tree guard of 1.5 m height shall be provided as specified by Employer's Representative.

The planted trees, garden etc. so developed shall be maintained in good condition during the execution and maintenance period of the Contract without any additional costs. The Contractor shall ensure the safety of plants and shall take all the activities such as re-plantation, manuring, use of pesticides, mulching, cutting etc. for growth of trees / plants and maintenance of plants.

7.31.16 Roads, Paths and Hard-standings

A comprehensive road network shall be provided to provide appropriate connectivity of the buildings and utilities, pump Station and around New treatment plant units i.e. main entrance, chlorine tonner shed, bulk chemical storage house, chemical house, clear water pump station, clear water reservoir, and other important units of treatment plant to link with the main road and the existing road network to permit vehicular access to each unit of the plant for necessary maintenance, delivery of consumables and personnel access. The internal roads shall be made as specifications and along the road, pre-cast cement concrete kerbs of approved shape and size shall be provided.

The road layout shall have due consideration to the storm water drainage system so as to prevent standing water in the plant area.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas.

Hard standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the plant area and leave again without going in reverse or carryout complicated maneuvers in order to exit the plant.

Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Employer's Representative.

7.31.17 Security Cabins

Necessary security cabins shall be provided at each gate. The cabin building shall be of permanent type with minimum area of each cabin as 10 m^2. The detailed requirement is as given in "Requirements for building units other than Administration and Control building"

7.31.18 Workshop

Workshop of minimum area 75 m^2 area shall be provided. The detailed requirement is as given in "Requirements for building units other than Administration and Control building".

7.32 PARTICULAR TECHNICAL REQUIREMENTS – MECHANICAL WORKS

7.32.1 Horizontal Split Casing Centrifugal Pump

It is proposed to provide Horizontal Split Casing Centrifugal pump set of following specifications in all Raw water, Clear water & Distribution water pumping station.

Contractor has to design these pumps Stations complete for Civil, Mechanical, Electrical & Instrumentation works. The pump Stations shall be designed to accommodate installation of pump sets for different sections as per scope of work and as mentioned below.

7.32.1.1 General Features of Pumps

The clear water pumps shall have the following features:

a) Type of Clear Water Pump Sets,

Horizontal Split Case type pumps with squirrel cage LT Induction Motors of suitable ratings. Pump drive shall be of 0.415 kV rating.

b) NPSH

The NPSH provided by the installation of pumps (NPSHa) shall be at least 0.5 m more than that required for the pump (NPSHr) in all conditions of operation.

7.32.1.2 Specifications for Horizontal Split Casing Pumps

The design, manufacture and performance of the pumps specified herein shall comply with the requirements of the applicable Codes and Standards, as follows, but not limited to:

Table22: Specification for Horizontal Split Casing Pumps

No.	Standard	Title
1	IS 6595 (Part II)	Horizontal centrifugal pumps for clear, cold and fresh water.
2	IS 9137	Code for Acceptance Tests for Centrifugal, Mixed flow and Axial pumps.
3	IS 13537	Technical specification for centrifugal pumps - Class 2
4	ISO 5199	Standards of the Hydraulic Institute of USA.
5	ISO 2373	Balancing of impeller.
6	IS 5120	Performance test of pumps
7	IS 11732	Mechanical Balancing

7.32.1.3 Features & Material of Construction

Table23: Features and Material of Construction Split Casing Pumps

Casing	Horizontal split casing
Drive	Direct
Flange Drilling	IS 1538
Prime mover	Electric Motor (Refer Electrical section)
Casing	Cast Iron IS: 210 – Gr. FG 260 with 2 % Ni
Impeller & impeller rings	SS (CF8M)
Shaft	SS (AISI 410)
Shaft Sleeve	SS (AISI 410)
Casing rings	SS (CF8M, CA15)
Glands	Bronze grade LTB2 of IS 318
Gland Packing	Graphite Asbestos
Lantern Rings	CI
Gaskets	Manufacturer's Standard durable.
DRIVE DATA	
Motor	0.415 KV motor, (TEFC) Squirrel cage induction motors For details refer to Motor Specifications

7.32.1.4 Accessories Required To Be Supplied With Pump

The contractor is supposed to provide at least the following accessories:

- Base Plate
- Foundation Bolts
- Coupling

7.32.2 VALVES

7.32.2.1 AIR VALVE

The valve shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly the valve shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high

to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipework during normal working conditions.

Air valves shall thus be designed to automatically operate so that they will;

- positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
- not blow shut under high velocity air discharge; and
- exhaust accumulated air under pressure while the pipe is flowing full of water

All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line.

Air valves shall be Kinetic double orifice type as per IS 14845 and tamper proof unless otherwise directed by the Employers Engineer. A buoyant rigid float shall seal the large orifice and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures. All air valves shall be provided with isolating sluice valve and flanged end connection.

The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.

All branched outlets including air valve tees will be provided with one ½" BSP coupling duly plugged for measurement of pressure in due course. The closing plug shall be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and shall be provided with copper washer for sealing.

Material of construction of air valve shall comply with following requirement.

Body and cover	Grade GGG 40
Float	Polycarbonate up to 50 NB / SS 304-above 50 NB
Internal Linkages	Stainless Steel 304
Gasket, seal ring, sealing face	EPDM
Vent valve	Brass
Coating	Electro-statically applied epoxy resin- Internally and externally (min 250 micron)

7.32.2.2 Non-Return Valve/ Rubber Flap Check Valve

i. The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
ii. Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.
iii. Dual plate check valves shall conform to API 594 and API 598. They shall have metal to metal sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one

another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition. Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

iv. The minimum body-wall thickness shall conform to those given in Table 1B of API Standard 594.

v. The face-to-face dimensions of valves (including valves with ring-joint facings) shall conform to those mentioned in Table 2B of API Standard 594.

vi. The valve body shall be furnished with a clearly visible forged, machined-in, or die-stamped arrow to indicate the direction of flow through the valve.

vii. Maximum permissible seat leakage is 7cc/Hr/cm nominal diameter of valve.

viii. Material of construction of valves shall comply with following requirements

Pressure rating	PN 16
Body	ASTM, A 395
Plate	ASTM, A 351 Gr CF8M
Hinge Pin /Stop Pin/wetted parts	SS AISI 316
Springs	SS. ASTM A 313
Seat	SS AISI 316
Retainer	SS-304

7.32.2.3 GATE VALVE/SLUICE VALVE

Sluice valve shall generally confirm to IS 14846 and shall be **resilient seated type**. They shall be of non-rising spindle type except for the valves for bypass. The gate face rings shall be securely pegged over the full circumference. Valve of 400 mm and above shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm. Valve of 200 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valve of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N.

Valves spindles and hand wheels shall be positioned to give good access for operational personnel. Hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Valves shall have two position marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

All valves on pump suction and delivery piping shall be with electrical actuators. All Sluice valves shall be open end tested

The body and bonnet shall be of Ductile cast iron of grade GGG-40, wedge with fully encapsulated EPDM rubber W-270 (approved for drinking water) and seals of NBR. The valves should be with replaceable stem nut and replaceable sliding shoes. Valve stems shall be of single piece thread rolled. Valve shall have 3 "O" rings of NBR for stem sealing. Gate valve shall be compatible for burried applications without valve chamber. Face-to-face dimensions as per BS 5163-89/IS 14846-PD/EN 558F4 and flange connections as per IS 1538, Maximum Valve operating torque should be at least 40% less than the torque as stated in the standard EN 1074. Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 250 microns. The EPDM rubber & Epoxy Powder should be approved by W 270.

Material of Construction:

Body, Bonnet	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12
Wedge (fully rubber encapsulated)	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12 encapsulated with EPDM rubber - W270 approved grade.
Spindle/Stem	SS: IS: 6603 12Cr13/22Cr 13;AISI 410/AISI 420
Stem Nut	Brass
Bonnet Gasket	EPDM rubber - W270 approved grade
Internal Fasteners	Stainless Steel SS316/304
Stem Sealing	Toroidal NBR sealing rings (Min 03 'O' Rings)
Coating	Inside & Outside epoxy powder coated; DFT minimum 250 micron, shade RAL 5005 (BLUE)

7.32.2.4 PLUNGER TYPE FLOW CONTROL VALVES

Plunger type control valve shall be of DI with one piece body of ductile cast iron of grade GGG-40 and all internal parts of stainless steel. Piston guides shall be of bronze welded overlay & micro-finished and bearing bush of zinc free Bronze. Valve/profile sealing seat shall be in the no-flow zone. Double sealing effect between the body and the plunger shall be by Quadring Seal (twist free operation). The valve shall be designed to operate smoothly throughout the specified flow range without cavitation. Corrosion protected medium free bearing in the body by way of double O-ring seal and encapsulated shaft seal. There shall be no obstacles in the main flow passage except the plunger and the attached control cylinders. Plunger shall be by means of stainless steel crank drive mechanism. Face-to-face dimensions shall be as per EN558-1 basic series 15 and 1.5xDN from DN500 and flange connections as per EN1092-2.

Material of Construction:

Body	Ductile iron to EN-JS 1030 (GGG-40)
Crank Gear	Stainless Steel 304 up to DN600 and Epoxy coated GGG40 for DN700 and above.
Plunger	Stainless Steel 304
Control Cylinder	Stainless Steel 304
Shaft	Stainless Steel 420 (1.4021)
Bearing Bush	Zinc free Bronze
Piston Guides	Bronze overlay welded and micro-finished
Surface Protection	Epoxy coating min. 150 microns, color RAL 5005 Blue.

7.32.3 Electric Actuator

The actuators shall be suitable for use on a nominal volt phase Hz power supply and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self contained, sealed enclosure.

In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc shall be carried out without the removal of any actuator covers over an Infra red interface. Sufficient commissioning tools shall be provided with the actuators and must meet the enclosure protection and certification levels of the actuators. Commissioning tools shall not form an integral part of the actuator and must be removable for secure storage/authorised release. In addition, provision shall be made for the protection of configured actuator settings by a means independent of access to the commissioning tool.

The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.

Actuators shall be suitable for indoor and outdoor use. The actuator shall be capable of functioning in an ambient temperature ranging from 15 to 45 degree C, up to 100% relative humidity.

Actuators for hazardous area applications shall meet the area classification, gas group and surface temperature requirements specified in data sheet.

Actuator sizing

The actuator shall be sized to guarantee valve closure at the specified differential pressure and temperature. The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal. For linear operating valves, the operating speed shall be such as to give valve closing and opening at approximately 10-12 inches per minute unless otherwise stated. For 90° valve types the operating time should be specified.

Enclosure

Actuators shall be 0-ring sealed, watertight to /IP68 7m for 72hrs, NEMA 4, 6. The motor and all other

internal electrical elements of the actuator shall be protected from ingress of moisture and dust when the terminal cover is removed for site for cabling, the terminal compartment having the same ingress protection rating as the actuator with the terminal cover removed.

Enclosure must allow for temporary site storage without the need for electrical supply connection.

All external fasteners shall be zinc plated stainless steel. The use of unplated stainless steel or steel fasteners is not permitted.

Motor

The motor shall an integral part of the actuator, designed specifically for valve actuator applications. It shall be a low inertia high torque design, class F insulated with a class B temperature rise giving a time rating of 15 minutes at 40°C(104°F) at an average load of at least 33% of maximum valve torque. Temperature shall be limited by thermostats embedded in the motor end windings and integrated into its control. Electrical and mechanical disconnection of the motor should be possible without draining the lubricant from the actuator gearcase.

Motor protection

Protection shall be provided for the motor as follows:

- Stall - the motor shall be de-energized within 8 seconds in the event of a stall when attempting to unseat a jammed valve.
- Over temperature - thermostat will cause tripping of the motor. Auto-reset on cooling
- Single phasing - lost phase protection.
- Direction – phase rotation correction.

Gearing

The actuator gearing shall be totally enclosed in a oil-filled gearcase suitable for operation at any angle. Grease lubrication is not permissible. All drive gearing and components must be of metal construction and incorporate a lost-motion hammerblow feature. For rising spindle valves the output shaft shall be hollow to accept a rising stem, and incorporate thrust bearings of the ball or roller type at the base of the actuator. The design should be such as to permit the opening of the gearcase for inspection or disassembled without releasing the stem thrust or taking the valve out of service. For 90° operating type of valves drive gearing shall be self locking to prevent the valve backdriving the actuator.

Hand operation

A handwheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It should be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.

Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and should be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through stroke and 800N for seating/unseating of the valve.

Drive bushing

The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox. input shaft. Normally the drive bush shall be positioned in a detachable base of the actuator. Thrust bearings, when housed in a separate thrust base should be of the sealed for life type.

Torque and turns limitation

Torque and turns limitation to be adjustable as follows:

- Position setting range – multi-turn: 2.5 to 100,000 turns, with resolution to 15 deg. of actuator output.
- Position setting range – direct drive part turn actuators: 90° +/-10°, with resolution to 0.1 deg. of actuator output.
- Torque setting: 40% to 100% rated torque.

Measurement of torque shall be from direct measurement of force at the output of the actuator. Methods of determining torque-using data derived from the motor such as motor speed, current, flux etc are not acceptable A means for automatic "torque switch bypass" to inhibit torque off during valve unseating and "latching" to prevent torque switch hammer under maintained or repeated control signals shall be provided.

The electrical circuit diagram of the actuator should not vary with valve type remaining identical regardless of whether the valve is to open or close on torque or position limit.

Remote valve position/actuator status indication.

Four contacts shall be provided which can be selected to indicate any position of the valve, Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.

The contacts shall be rated at 5A, 250V AC, 30V DC.

As an alternative to providing valve position any of the four above contacts shall be selectable to signal one of the following:

Valve opening, closing or moving

- Thermostat tripped, lost phase
- Motor tripped on torque in mid travel, motor stalled
- Remote selected

Actuator being operated by handwheel

Provision shall be made in the design for an additional 4 contacts having the same functionality. Provision shall be made in the design for the addition of a contactless transmitter to give a 4-20mA analogue signal corresponding to valve travel for remote indication when required. The transmitter will auto range to the set limits

Local position indication

The actuator display shall include a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully closed in 1% increments. Valve closed and open positions shall be indicated by symbols showing valve position in relation to the pipework to ensure that valve status is clearly interpreted. With main power on the display shall be backlit to enhance contrast at low light levels and shall be legible from a distance of at least 6 feet (2m).

Red, green, and yellow lights corresponding to open, closed, and intermediate valve positions shall be included on the actuator display when power is switched on. The digital display shall be maintained and updated during handwheel operation when all power to the actuator is isolated.

In addition, the actuator display shall include a separate text display element with a minimum of 32 characters to display operational, alarm and configuration status.. The text display shall be selectable between English and one of the following languages: Hindi or Marthi. Provision shall be made to upload a different language without removal of any covers or using specialized tools not provided as standard with the actuator. Provision shall be made to orientate the actuator display through increments of 90degres.

Local torque Indication:

The digital display shall be capable of indicating real time torque and valve position simultaneously, both being displayed in 1% increments of valve position and actuator rated torque. In addition torque shall also be displayed in horizontal bar graph form.

Integral starter and transformer

The reversing starter, control transformer and local controls shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The controls supply transformer shall be fed from two of the incoming three phases and incorporate overload protection. It shall have the necessary tappings and be adequately rated to provide power for the following functions:

- Energization of the contactor coils.
- 24V DC output for remote controls.
- Supply for all the internal electrical circuits.

Local controls

The actuator shall incorporate local controls for Open, Close and Stop and a Local/Stop/Remote mode selector switch lockable in any one of the following three positions: local control only, stop (no electrical operation), remote control plus local stop only. It shall be possible to select maintained or non-maintained local control.

The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.

Provision shall be made to orientate the local controls through increments of 90 degree.

Control facilities

The necessary control, wiring and terminals shall be provided in the actuator for the following functions:

Open and close external interlocks to inhibit local and remote valve opening and/or closing control. It shall be possible to configure the interlocks to be active in remote control only.

Remote controls fed from an internal 24V DC supply and/or from an external supply between 20V and 120V AC or 20V and 60 V DC, to be suitable for any one or more of the following methods of control:

- ✓ Open, Close and Stop control.
- ✓ Open and Close maintained or “push to run” (inching) control.
- ✓ Overriding Emergency Shut-down to Close (or Open) valve from a normally closed or open contact.
- ✓ Two-wire control, energise to close (or open), de-energise to open (or close).

It shall be possible to reverse valve travel without the necessity of stopping the actuator. The motor starter shall be protected from excessive current surges during rapid travel reversal.

The internal circuits associated with the remote control and monitoring functions are to be designed to withstand simulated lightning impulses of up to 2kV.

Provision shall be made for operation by distributed control system utilising the following network systems.

- Modbus
- Profibus
- Foundation Fieldbus
- DeviceNet
- Pakscan

Monitoring facilities

Facilities shall be provided for monitoring actuator operation and availability as follows:

Monitor (availability) relay, having one change-over contact, the relay being energized from the control transformer will de-energise under any one or more the following conditions:

- Loss of main or customer 24V DC power supply
- Actuator control selected to local or stop
- Motor thermostat tripped
- Actuator internal fault

Where specified, provision shall be made for contacts to provide discreet indication of one or more of the following:

- Remote selected
- Thermostat trip
- Actuator fault

Actuator text display indication of the following status/alarms:

- Closed Limit, open limit, moving open, moving closed, stopped
- Torque trip closing, torque trip opening, stalled
- ESD active, interlock active
- Thermostat trip, phase lost, 24V supply lost, Local control failure
- Configuration error, Position sensor failure, Torque sensor failure
- Battery low, power loss inhibit

Integral datalogger to record and store the following operational data:

- Opening last /average torque against position
- Closing last /average torque against position
- Opening motor starts against position
- Closing motor starts against position
- Total open/closed operations
- Maximum recorded opening and closing torque values
- Event recorder logging operational conditions (valve, control and actuator)

The datalogger shall record relevant time and date information for stored data.

Datalogger data is to be accessed via non-intrusive IrDA communication. Sufficient standard intrinsically safe tools shall be provided for downloading datalogger and actuator configuration files from the actuators and subsequent uploading to a PC. The actuator manufacturer shall supply PC software to enable datalogger files to be viewed and analysed.

Wiring and terminals

Internal wiring shall be tropical grade PVC insulated stranded cable of appropriate size for the control and 3-phase power. Each wire shall be clearly identified at each end.

The terminals shall be embedded in a terminal block of high tracking resistance compound.

The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal and shall be provided with a minimum of 2 threaded cable entries with provision for a maximum of 4.

All wiring supplied as part of the actuator to be contained within the main enclosure for physical and environmental protection. External conduit connections between components are not acceptable.

A durable terminal identification card showing plan of terminals shall be provided attached to the inside of the terminal box cover indicating:

- Serial number
- External voltage values
- Wiring diagram number
- Terminal layout

The code card shall be suitable for the contractor to inscribe cable core identification alongside terminal numbers.

7.32.4 EXPANSION BELLOWS

The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipments. Stainless steel AISI 304 expansion bellows which can take radial and axial misalignment of minimum 1 percent of valve nominal size with tie rods shall be included in the suction and delivery pipe work of all pumps as well as on delivery header for easy dismantling. All loose flange shall be secured to fixed flanges by suitable tie-bolts. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange or other suitable sealing device. The final outlet connection of the pipe work shall match the connecting point of the transmission main.

7.32.5 PRESSURE REDUCING VALVES

The Pressure Reducing Valve shall reduce higher pressure to lower preset downstream pressure regardless of fluctuating demand or varying upstream pressure head.

Main Valve: The main valve shall be a center guided, diaphragm actuated globe valve of either oblique (Y) or angle pattern, design. The body shall have a replaceable, raised, stainless steel seat ring. The valve shall have an unobstructed flow path with no stem guides, bearings, or supporting ribs. The body and cover shall be ductile iron. All external bolts, nuts, and studs. shall be Duplex coated. All valve components shall be accessible and serviceable without removing the valve from the pipeline.

Actuator: The actuator assembly shall be double chambered with an inherent separating partition between the lower surface of the diaphragm and the main valve. The entire actuator assembly (seal disk to top cover) shall be removable from the valve as an integral unit. The stainless steel valve shaft shall be center guided by a bearing in the separating partition. The replaceable radial seal disk shall include a resilient seal and shall be capable of accepting a V-Port Throttling Plug by bolting.

Control System: The control system shall consist of a 2-Way adjustable, direct acting, pressure reducing pilot valve, a needle valve, isolating cock valves, and a filter. All fittings shall be forged brass or stainless

steel. The assembled valve shall be hydraulically tested and factory adjusted to customer requirements. The required numbers of switch/contacts meet requirements for PLC system.

Quality Assurance: The valve manufacturer shall be certified according to the ISO 9001 Quality Assurance Standard. The main valve shall be certified as a complete drinking water valve.

7.32.6 DISMANTILING JOINTS

CI Double flanged Dismantling joints shall be installed in such a manner that valves can be dismantled without stress to the joints. Dismantling joints shall be suitable for installation with all valves of different diameters.

The dismantling joint shall be designed for a hydrostatic pressure of 10 kg/sq.cm. The sliding flange shall be machined smooth and shall slide at least 30 mm to disengage fully mating flange. All the fasteners for the dismantling joint shall be of SS 304. These shall be completely leak proof with proper gasket arrangement. Flange dimensions shall conform to latest relevant IS code. Flanged specials shall be supplied with required nuts, bolts and rubber gaskets. The dismantling joint shall be internally and externally coated with hot applied (dip) bituminous paint.

7.32.7 Electrically Operated Hoists

Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section.

Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 a wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sq.m.

Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in ‘OFF’ position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer’s works.

7.32.8 Hand Operated Hoists and Trolleys

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

7.32.9 Manually Operated Travelling Crane

The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

Trolley and Chain Pulley Block

The chain pulley block shall be operated on the lower flange of the bridge girder.

The load chain shall be made of alloy steel as per IS: 3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

The hand chains for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS: 4460.

The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

The travelling trolley frame shall be made of rolled steel conforming to IS: 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalising pin.

Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per BS: 2903/IS: 3815

The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

Ratchet and Pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.

7.32.10 Electrically Operated Overhead Travelling Crane

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573, IS:3177 or relevant internationally approved standards.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS: 2062, BS: 4360 or relevant internationally approved standards. The bridge shall be designed to carry safely the loads specified in IS: 807, BS: 2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads. The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrustor brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per stand with minimum ultimate tensile strength of 1.6 X 106 kN/m2 of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS: 2266. Rope drums shall be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS: 3177, BS: 466 or relevant internationally approved standards.

Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS: 436, IS: 4460 and BS: 721 or relevant internationally approved standards.

Name Plate showing the capacity, year of manufacture and rated capacity of hoist, in figures not less than 150 mm height, shall be placed on each side of the crane girder.

The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided.

Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

a. `Start' and `Stop'.

b. Long travel - `Right' and `Left'.

c. Cross travel - `To' and `Fro'.

d. Hook - `Hoist' and `Lower'.

e. Red indicating lamp for supply `ON' indication.

Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent overtravel for each of the following:

a. For `UP' and `Down' motions of the hook.

b. Long travel motion

c. Cross travel motion

Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching' the cross travel and down shop travel motions.

Sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

All electrical equipment shall be fully tropicalised.

Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

7.33 PARTICULAR TECHNICAL REQUIREMENTS – ELECTRICAL WORKS

7.33.1 General

The scope of work includes design, equipment selection, manufacture, inspection at Contractor's or his Sub-Contractor's works, supply, installation (including storing, unloading and transferring the material / equipment to Contractor's storage area, maintaining equipment / material in safe custody and assembling the elements of the equipment and installing at the place of work), testing and commissioning of the plant equipment/ electrical system on 'Design Build& Operate' basis and dismantling of existing electrical equipment and handed over the existing equipment to Employer's Representative at the location as directed by the Employer Representative. After successful commissioning and trial run of the plant, it should be handed over to the Employer. The Contractor shall also be responsible for Operation &Maintenance (O&M) of the plant for 5 years after it is formally taken over by the Employer. The Contractor shall submit their design calculations/ drawings based on 'Design criteria for electrical equipment/system' for Employer's review and approval. These specification covers substations, transformers, HV/LV switchboards, energy efficient motors, soft starters, capacitors, HV and LV power cables and control cables, and other allied equipment, etc. along with the specifications for workmanship, laying cables, lighting system, earthing systems, lightning protection etc. for this water supply project. It shall be the responsibility of the Contractor to design the electrical system based on the selection of the mechanical equipment.

The Bidder shall make his own estimate of sizes, ratings and quantities for, substation equipment, all plant items and miscellaneous systems such as earthing, lightning protection, lighting, auxiliary power distribution, etc. Design of electrical system (i.e. Substation, transformers and other electrical equipment) shall be based on Stage-I (i.e. year up to 2033) only. However, facility for upgrade/ expansion of all equipment to cater Stage-II load shall have to be considered during design-engineering stage. Sufficient space in the switchyard and switchboard/ control room shall be provided for expansion/ up-gradation of switchyard / electrical equipment/ switchboard for Stage-II load. It should be clearly understood that the Contract will be on 'Design Build & Operate' basis and no variation will be allowed for items of works not foreseen or omitted by the Bidder at the bidding stage, except where specifically indicated in the bid documents.

All equipment offered shall comply with the requirements specified in the latest editions of applicable Indian/ International Standards and shall also comply with the good engineering practices.

Contractor shall design the electrical system on the basis of 'Design Criteria' and to be submitted for Employer's approval. Contractor shall incorporate any changes/ suggestions in the drawings to suit site conditions and design criteria and standard engineering practice and resubmit for approval to Employer's Representative.

The Contractor shall possess the valid electrical Contractor's license of appropriate class from the concerned statutory bodies governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations.

All type (as applicable), routine and acceptance tests shall be conducted in the presence of Employer/ Employer's Representative / Third Party Inspector on all the equipment as per latest applicable IS/IEC at no extra cost. Typical type test reports for other equipment shall be submitted by the Contractor for approval by Employer/ Employer's Representative.

All commissioning tests shall be carried out in the presence of Employer/ Employer's Representative and approval for the same shall be obtained before commissioning and installation. All test reports shall be properly maintained by the Contractor duly approved by the statutory bodies and shall be handed over to the Employer after completion of the job. All instrument and accessories required for testing and commissioning of the equipment specified herein shall be provided by the Contractor at no extra cost to the Employer.

Liaison with State Electricity Board and other Government organization/ statutory bodies for obtaining Power supply/ other clearance shall be Contractor's scope. After completion of installation work, the Contractor shall arrange for inspection and obtain approval from the concerned statutory bodies. Any fees that are to be paid to such statutory bodies for testing, inspection or calibration shall be paid by the Contractor. Any modification / revision in the equipment / installation of equipment as required by the statutory bodies shall be carried out by the Contractor. All such costs / fees for revisions / modifications shall be deemed to be included in the prices of supply, installation, testing and commissioning of equipment as quoted by the Contractor.

7.33.2 Transformer Size selection Criteria

The transformer size shall be determined from the estimation of the simultaneous maximum demand based on the power rating of motors and other loads and their operating / running periods.

The design shall be based on maximum nos. of main motors working and the corresponding auxiliary loads including WTPs shall be considered for sizing of transformer.

Appropriate values of load factor, diversity factor, power factor and efficiency shall be considered for each type of load. Improvement in power factor due to capacitors shall not be considered. Five percent (5%) contingency shall be added to the simultaneous maximum demand thus calculated and the next standard size of transformer as per IEC shall be selected.

Two such transformers shall be provided for 100 % redundancy at each site. The design calculations for transformer sizing shall be subject to the approval of the Employer's Representative.

7.33.3 Electrical System for Proposed Intake works, Raw water system and 10 MLD Water Treatment Plant

A new reliable 11kV connection shall be taken for proposed Intake works, Raw water system and WTP near Sidhwan canal.

The new substation shall be capable for feeding the entire load for proposed WTP and Clear water pump station (up to Stage-II requirement) with adequate voltage and power quality.

Incoming 11 KV supply shall be step down by distribution transformers, which in turn shall feed the main LV indoor switchboard. 100% redundant transformers are proposed (i.e. one working + one standby) to feed the entire load of the proposed pump system. The transformer neutral is to be earthed to limit the earth fault current. The transformers (and the cables to the LV switchboard) shall be suitable for outdoor application.

Necessary metering, protection and indication/ annunciation are to be provided on all the switchboards

7.33.4 Electrical System for Proposed Water Distribution Pump Stations

A new reliable 11kV connection shall be taken for proposed Water distribution pump stations at Leisure valley and Rose garden. The new substation shall be capable for feeding the entire load of proposed WDS (upto Stage-II requirement) with adequate voltage and power quality.

Outdoor Substation located adjacent to proposed Leisure valley and Rose garden water distribution pump stations shall be provided with RCC foundation. 11 kV overhead lines to be terminated on a 4-pole structure through suitable HV disconnections with earthing switch and all metering and protection arrangements and Lightning arresters shall be provided on the incoming lines.

Incoming 11 KV supplies shall be step down on distribution transformers, which in turn shall feed the main LV indoor switchboard. 100% redundant transformers are proposed to feed the entire load of the proposed pump station. The transformer neutral is to be earthed to limit the earth fault current. The transformers (and the cables to the LV switchboard) shall be suitable for outdoor application.

Both transformers shall also have capability of supply power to the LV auxiliary loads of proposed Leisure valley and Rose garden water distribution pump stations, which includes loads such as electrical valve actuators, control and instrumentation panels, EOT crane, LV auxiliary motors and indoor and outdoor lighting load.

Main LV switchboard shall be located in electrical room of Water Distribution Station receive power from the transformers to feed the individual loads. Suitable space in the Pumping station shall be taken for future expansion of main LV switchboards. Outgoing Feeders for both VFD & Motor starters shall be taken in main LV Switchboard.

LV capacitor banks with control panel consisting of automatic power factor correction (APFC) relay are to be proposed across each LV bus section of each LV switchboard.

Necessary metering, protection and indication/ annunciation are to be provided on all the switchboards

7.34 PARTICULAR TECHNICAL REQUIREMENTS - INSTRUMENTATION, AUTOMATION AND CONTROL SYSTEM WORKS

7.34.1 GENERAL

This section outlines the particular requirements for the instrumentation, automation and control systems. Unless specified in this section to the contrary instrumentation Plant provided by the Contractor and workmanship shall comply with the General Instrumentation, Automation and Control Requirement Chapters of these Requirements.

7.34.2 THE SCOPE and Battery Limits

The scope of instrumentation, control and automation (ICA) works shall comprise the design, manufacture, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete supervisory, instrumentation, control and automation system including the interfaces required to provide monitoring and control for a safe and efficient operation of plant, equipment and system.

The Contractor shall submit and obtain approval of the instruments and the system from the employer before beginning the detailed control system design.

The minimum scope of work shall include but not limited to:

- **MASTER CONTROL CENTRE (MCC) at proposed Water Treatment Plant**

Design, supply, install, test and commission a dual redundant control system. PLC, RTU & SCADA shall include but not limited to process controller including its central process units (CPUs), communication modules, input-output (I/O) modules, control networks, operator workstations with 32" LED display, engineering workstation with 60" LED display and printers.

This system shall be designed in order to control, operate and monitor the following:

- New water treatment plant
- Raw water reservoirs and pumping station
- Treated Water reservoirs and Pumping station

- **Field Instrumentation**

Design, supply, install, test and commission field instrumentation for the Entire Water supply system including WTP, RWPS and CWPS.

- **Instrumentation Schedule**

A listing of the basic instrumentation and control system to be supplied, installed, tested and commissioned under this water supply scheme shall include, but not be limited to, the list given in Table below.

	Service	**Type of Instrument**	**Instrument Function**
I.	**Flow Measurement**		
i.	Flow measurement near plant inlet	Open channel flow meter (Ultrasonic)	Transmission, Indication and recording of flow rates and totalisation of flow.
ii.	Filtered water flow	Electromagnetic flow meter – full bore	Transmission, Indication and recording of flow rates and totalisation of flow.
iii.	Backwash water flow	Electromagnetic flow meter – full bore	Transmission, Indication and recording of flow rates and totalisation of flow.
iv	Flow measurement of waste water	Electromagnetic flow meter – full bore	Transmission, Indication and recording of flow rates and totalisation of flow.
v.	Flow measurement of air for filter wash	Anubar	Transmission, Indication and recording of flow rates and totalisation of flow.
vi	Rate of flow for filter bed	Ultrasonic	Transmission, Indication and recording of flow rates and

	Service	Type of Instrument	Instrument Function
			totalisation of flow.
vii	Bulk water Flow measurement at all DMA's	Electromagnetic flow meter – full bore	Transmission, Indication and recording of flow rates and totalisation of flow.
II.	**Level Measurement**		
i.	Water level in clear water sump	Ultrasonic level measurement	Monitoring of water level, continuous measurement trending of data and initiation of alarms
		Conductivity type level switches for high and low level detection	Tripping of pumps at low water level and generating an alarm
ii.	Water level in Backwash water tank	Ultrasonic level measuring system	Monitoring of water level continuous measurement, trending of data and initiation of alarms
		Conductivity type of level switches for high and low level detection	Tripping of pump at high water level and starting at low level, and generating alarms
iii.	Water level in clarified water channel	Ultrasonic level measuring system	Monitoring of water level continuous measurement and alarm
iv.	Water level in filter water channel	Ultrasonic level measuring system	Monitoring of water level continuous measurement and alarm
v.	Level in coagulant solution preparation tanks	Ultrasonic level measuring system	Monitoring of level in coagulant solution preparation tanks and generating alarm
		Conductivity type of level switches	As a backup protection to level sensing
vi.	Level in coagulant service tanks and PE dosing tank	Sight glass	Indication of level in coagulant service tanks and PE dosing tank

	Service	Type of Instrument	Instrument Function
Vii	Level in thickened sludge tank	Ultrasonic level measurement	Monitoring of water level continuous measurement trending of data and intimation of alarm
viii	Level in CWR's, and UGSR's	Ultrasonic level measurement	Monitoring of water level continuous measurement trending of data and intimation of alarm
		Conductivity type of level switches for high and low level detection	Tripping of pump at high water level and starting at low level, and generating alarms
III	**Pressure Measurement**		
i.	Head loss measurement across filter bed	DP transmitter and panel mounted indicator system	Differential level transmitter for filter bed for measuring head loss across bed
ii.	Pressure in BW water header	Pressure measurement system consisting of a pressure transmitter and panel mounted indicator system	Pressure transmission, monitoring and generating an alarm
iii.	Pressure in BW air header	Pressure measurement system consisting of a pressure transmitter and panel mounted indicator system	Pressure transmission, monitoring and generating an alarm
iv.	Pressure measurement on blower outlet	Pressure gauge	Pressure monitoring of air; manually
V	Sludge transfer pump	Pressure gauge	Pressure monitoring
vi	Centrifuge feed pump	Pressure gauge	Pressure monitoring
	Pressure measurement on	Pressure measurement system consisting of a	Pressure transmission, monitoring and generating an

	Service	Type of Instrument	Instrument Function
	pumping mains	pressure transmitter and panel mounted indicator system	alarm
IV.	**Water Parameter Monitoring Instruments**		
i.	pH of water for raw water, clarified water and filtered water measurement	pH measuring instrument	Continuous monitoring of pH and generating alarm. Trending of data
ii.	Turbidity measurement	Turbidity meter	Continuous monitoring of turbidity and generating alarm. Trending of data
iii.	Chlorine residual measurement	Chlorine residual analyzer	Continuous monitoring of residual chlorine and generating alarm. Trending of data
V.	**Miscellaneous**		
i.	Chlorine leakage in chlorine / cylinder room	Chlorine leak detector	Monitoring Cl2 in air generating alarm at instance of leakage and switching on chlorine neutralization system
ii.	Operating panel for filter bed	Console	Manual/automatic controlling washing sequence of bed
iii	Operating panel for Clariflocculators	Clarifier Panel	Manual/automatic control of clariflocculators
VI.	**Automation**		
I	Filter bed	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically
ii	Clariflocculators	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically

	Service	Type of Instrument	Instrument Function
iii	Chemical dosing	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically
iv	Chlorination	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically
v	Sludge handling	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically
vi	Raw and Clear water pumping stations	PLC based instrument control panel	Monitoring, controlling, operation automatically, semi automatically
vii	SCADA	Software + Hardware	For monitoring, operation & control of plant
viii	Information technology	Software + Hardware	For inter connection raw water pumping station, clear water pumping station, WTP & UGSRs & Water distribution pump stations
ix	RTU panels	Hardware + Software	For data transmission of remote field instruments like flowmeters, pressure transmitters and level transmitters to MCC.

- **Communication Network**

Interface equipment to enable communication between field instruments, PLC's, RTU's, and SCC SCADA at WTP's and UGSRs and Water distribution pump stations.

Supply, installation, testing commissioning of RTU's along with GPRS at UGSR's to transmit flow, level and pressure data to MCC for monitoring and control.

The communication equipment required to achieve this interfacing complete with all required accessories shall be supplied under this contract.

- **Data Acquisition and processing**

The data acquisition, processing and interfacing with the Master Control Centre of entire water supply scheme of ABD area is covered under this package.

- **System Console**

Control room furniture(system console) include but not limited to control console for placing dual redundant workstations and two printer compartments, desk for one engineering workstation, ODMS workstation and printer compartment and chairs .The system console design shall be submitted to the Employer for prior approval.

The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers (on approval by the Employer's representative), transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.

7.34.3 Design Requirements for Instrumentation, Control, Automation and SCADA Systems

The instrumentation, control, automation SCADA installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer.

7.34.4 Design criteria for Instrumentation, Control, Automation and SCADA Systems

7.34.4.1 Instrumentation System

a) Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

b) all instruments shall be suitable for continuous operation;

c) all digital outputs shall be volt free;

d) all instrumentation systems for use out of doors shall be protected to IP 65 for sensors and transmitters, while enclosures under submersible conditions shall be protected to IP68;

e) all analogue displays shall be of the digital type with no moving parts utilizing back lit liquid crystal diode technology;

f) For transmitting instruments, output signal shall be 4-20 mA DC linear having two wire system.

g) Unless otherwise stated, overall accuracy of all measurement systems shall be ±0.5% of measured value, and repeatability shall be ±0.5%.

h) After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.

i) The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

j) The instruments shall be designed to work at extremes of the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion.

k) Lockable enclosure shall be provided for the field mounted instruments wherever required.

l) All field instruments, and cabinets / panel-mounted instruments shall have tag plates / name plates permanently attached to them.

m) The performance of all instruments shall be unaffected for the ±10% variation in power supply voltage and ±5% variation in frequency simultaneously.

n) All wetted parts of sensors shall be made out of non-corrosive material capable of working with chlorine content of 5 ppm.

o) For all instruments (transmitting analogue signals) installed in the field, surge protection devices (SPDs) shall be provided at both ends of the connecting cable for the protection against static discharges / lightning and electromagnetic interference.

p) Pressure transmitters shall be provided with two valve manifold and a test port, so that in situ calibration can be carried out.

q) Two wire transmitters shall be provided with on-line test terminals.

r) The ranges of all instruments shall be suitable for the application in the process.

s) Instruments of similar type shall be of same make for appropriate inventory of spares, ease of maintenance and training.

7.34.4.2 PLC System

PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC Panel interrogation power supply should be fully redundant.

PLC shall comprise of necessary processors, input/output (I/O) modules, communication interface modules and man-machine interface (MMI) required to perform the desired functions.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

PLC shall have the following attributes as a Hot-Standby configuration.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;

- it shall scan the inputs in time cycles and update the status of its outputs.

7.34.4.3 RTU System

RTU shall be designed in accordance with this specification. The RTU shall be of proven design and suited for water supply and distribution SCADA applications.

RTU design should aim to minimize power consumption and heat generation. It should be designed to work in remote installation by being of robust physical construction with immunity to electrical noise.

The RTU shall be assembled from modular units, for example, power supply module, CPU and communications module, communication interface modules and modules for input/output purposes. I/O and serial cards shall be able to be arranged in the RTU rack in any order.

Modules shall be interconnected via a suitably robust plug and socket method. It shall not be necessary to unscrew individual wires/cables, both internal RTU wiring and I/O wiring, to replace faulty modules. The failure of one module will not affect the performance of any other module.

A marshalling terminal area shall be incorporated with each RTU to provide terminations for field cables. This area can be located in the RTU cubicle itself for an RTU replacement but for new locations there should be a separate marshalling cubicle. The RTU and marshalling cubicles shall normally be bolted together to form a 2-bay cubicle suite. A separation plate may be located between the cubicles.

The RTU and the cubicles shall be designed to accommodate the actual number of input/outputs, plus spare capacity.

7.34.4.4 SCADA System

The SCADA shall be a fully dual redundant server integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant and water supply network inputs and outputs. The main process monitoring and control shall be by means of Visual Display Unit (min. 60 inch. LED monitor) based process operator workstations that shall be located in the central control room.

SCADA/HMI system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not affect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

7.34.5 Functional Design Specification (FDS, Sequence of Operation)

The Contractor shall propose the details of the sequence of operation for the water supply system, water treatment plant and pumping stations through careful study of the water supply scheme proposed. Further, the contractor shall be solely responsible to comply with any change/additional processes during the contractors design stages.

The Contractor shall submit a complete functional design specification (FDS) for approval by the Employer within 3 months of the award of the contract.

Functional design specification (FDS) for the SCADA system shall be combined with the FDS for instrumentation, control and automation to form a complete document and shall comply with the specification of the FDS for instrumentation, control and automation. This document shall serve as the primary mechanism by which the Employer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain any necessary clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall include a detailed block diagram of the PLC, RTU & SCADA system with a description of the communications scheme to be provided. The FDS shall include operational details of the SCADA system which have an effect on plant operations, such as power failure response, communication failure response, and automatic shut-down and start-up of the system.

The FDS shall include a description of the interface of the SCADA system witfDJBh any existing or planned future DAC (Digital Access Carrier) equipment.

The Contractor shall submit a preliminary FDS and obtain approval before the system architecture design is finalized or detailed design takes place. The Contractor shall formally notify the Employer for approval of any amendments or additions to the approved FDS. The final FDS shall be submitted for approval before submission of the factory acceptance test definition documents. The Contractor should take note of the importance of this obligation.

The FDS shall comprise an overall description of the system, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

7.34.6 Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed in General Instrumentation, Automation and Control System in accordance with the requirements detailed elsewhere in this specification.

7.34.7 Specifications for online water quality monitoring systems

This section covers the specification required for online water quality sensors to be provided under the contract. The system should be user friendly that operates & analyze in minimum interval without any need of reagents, chemicals, consumables with low maintenance and calibration requirement. It should be capable of integration with the SCADA system.

Online multi-parametric pH, Conductivity/TDS, Turbidity, free Chlorine at various points of water distribution and the reservoirs.

The system proposed should have adequate channels to accommodate above measurements and should have capacity to display up to total 10 parameters to future-proof the system as it is not envisaged to upgrade the controller for next few years.

The system should have capability to accommodate any additional sensors viz. ORP, Dissolved Oxygen, Nitrite as may be required by the project authorities from time to time.

Parameters will be monitored at different location as mentioned below:

Water quality monitoring station will contain the sensors and equipment to measure the below mentioned parameters.

1. pH
2. Turbidity
3. TDS
4. Conductivity
5. Residual Chlorine
6. Flow
7. Pressure

7.34.7.1 Multi-parameter Controller System Specifications:

It should be equipped with the following minimum features:

- USB-interface for data transfer, upgrading firmware etc.
- Control unit with keys and toggle switch for the quick selection of software functions
- With colour graphic display with backlight
- With integrated backup controller function
- Input voltage 90 - 264 VAC 50/60 Hz
- Line power consumption approx. 25 VA
- Max. power delivery 18 Watt
- 6 galvanically separated current outputs (0/4-20 mA) that can be assigned arbitrarily
- MODBUS communication protocol for the data integration with PLC and SCADA
- With Sensor ID recognition
- High EMC interference immunity
- Integrated lightning protection
- Should have the latest features of highly advanced Multi parameter Controller having capability of handling at least 4 sensors in a single controller configuration and more as and when required.
- Display should be with improved reading precision through special backlit graphic display
- Easy User Intuitive operating keys: including keys for functions such as: Measurement, calibration, set/system settings, additional keys for: confirmation/switching menu O.K. (OK), Escape (ESC) etc.
- Internal integrated Data logger with minimum data memory for up to 500,000+ data sets

- The Controller should be able to power all the sensors and terminals or accessories attached to it without having to need any additional power sources in the system for increased protection against lightening and possible electromagnetic interference.
- The system should start automatically after the power is reset to the system (in case of power failure).
- The controller should be low power consuming with consumption of less than 5W.
- Sensors connected to the system shall be automatically detected and initialized.
- No extra system configuration should be needed for substitute / replacement sensors.
- The system should have Service mode for cleaning/calibration/maintenance activities.
- It should be possible to download the data via the USB interface an extremely fast data exchange to USB memory stick.
- The system should be fully programmable with multiple levels of access control with help of Electronic-Key for data security and protection against non-authorized access to avoid any tampering or changes to the system configuration by unauthorized access.
- The controller should store the sensor configurations and calibrations
- The controller should have Logbook to record the data
- The supplier should provide the firmware update free of cost as and when they are available for the life time of the system.
- The system should have a status LED that gives reliable and fast information regarding function and status of system. And the Controller/controller should show a LED for diagnostic purposes on the front. This LED should show normal and malfunctions of the system at a glance.
- Data Output to Control System: The System should have the capability to transmit the required 4-20 mA Analog Outputs as a minimum.
- In addition to above, the system should have ability to output Profibus, Modbus/RS 485, RS 232, LAN, GPRS, GSM compatible signals in future with addition of respective module as and when required.
- The system should be able to operate on AC Power (100-240 AC)
- Ambient Conditions Operating temperature: -4 °C … +55 °C
- Storage temperature: -10 °C … +65 °C
- Housing Material – Non corrosive e.g. Acrylonitrile-Styrene-Acryloesterpolymer or better
- Protection Rating IP 66 / equivalent to NEMA 4X for controller
- Electromagnetic Compatibility: EN 61326, Class B; FCC Class A, EMC for indispensable operation
- Integrated Lightning Protection: According to EN 61326 enhanced overvoltage protection for the entire system, implemented in each component

7.34.7.2 Sensor Specifications:

i. pH Sensor Specifications:

- Integrated temperature measurement and compensation should be provided in the pH sensor.
- Sensor check function to detect broken glass of the pH electrode.
- The pH sensor should have galvanically separated input.
- Calibration history should be stored automatically in the sensor.

- Sensor calibration can be done in the laboratory or field.
- The pH combination electrodes should require very little maintenance and there should be no electrolyte replacement.

Technical Specifications:

- Measuring Range: pH – 4.00- 12.00 at least considering the wastewater environment
- Signal Output –Digital
- Sensor Check function should be available in the pH sensor
- Power Consumption: less than 0.5 Watt
- Temperature Sensor should be integrated in the pH sensor
- Temp Compensation: -5 to +50 Deg C
- Transient Voltage Protection should be integrated in the sensor
- Sensor body: Stainless Steel or better
- protection type : IP 68 for both Sensor and Cable
- Sensor Cable Length: 7 meter

ii. Conductivity/TDS Sensor:

- The sensor should have high measuring accuracy 4-electrode design with no influence by polarization effects at higher conductivity values.
- Should have measuring range of 0.00 µS/cm to 500 mS/cm.
- TDS and salinity measurement should also be integrated.

Technical Specifications:-

- Measuring Range: Conductivity: 0-500 mS/cm; Salinity: 0-70; TDS: 0-2000 mg/l
- Signal Output –Digital
- Power Consumption: less than 0.5 Watt
- Temperature Sensor should be integrated with conductivity measurement.
- Temp Compensation: -5 to +50 Deg C
- Max Pressure for Sensor: 10 Bar
- Input Power: Powered by the Controller
- Transient Voltage Protection should be integrated into the sensor
- Sensor Body: Titanium or equivalent
- Protection type : IP 68 for both Sensor and Cable
- Sensor Cable Length: 15 meters

iii. Turbidity Analyzer Specification:

Turbidity sensor shall be connected to the multi-parameter measuring system. It shall be equipped with the following features:

- Automatic cleaning system or better maintenance less and consumables free cleaning system
- Scattered light measurement
- Scratch-resistant sapphire measurement windows
- Sensor monitoring function
- Integrated lightning protection
- With screw / plug connector for connection of the sensor connection cable

- Measuring range (selectable): 0 to 1000 NTU
- Process variation coefficient according to DIN 38402 part 51:in the range up to 2000 FNU less than 1 %
- Repeatability or repeating limit DIN ISO 5725 or DIN 1319: less than 0.015 % or min. 0.006 FNU

Temperature range:
Operating range: 0 °C ... 60 °C
Storing range: -5 °C ... 65 °C

Material:
Measurement window: Sapphire
Enclosure shaft: V4A stainless steel 1.4571

Type of protection : IP 68 (with the sensor connection cable connected)

iv. Residual Chlorine Analyzer specification:

- Module for measuring free chlorine in water for use on raw/treated water panel with controller Useable in media with constant pH between 6-8.

Chlorine electrode:

- Range: 0-10 mg/l
- Resolution: 0.01 mg/l
- pH-Range: pH 6-8
- Electrochemical principle
- Temperature range: 5 - 45°C

Material:

- PVC, Silicone, Polycarbonate

Current of water needed:

In flow thru armature approx. 30 l/h.

Maximal pressure: Armature with electrode: max. 1 bar overpressure

v. Level Sensor:

Ultrasonic type level transmitters shall be microprocessor based and shall use digital signal processing technique for signal conditioning. The transmitter shall have facilities for storing the echo profile, manipulation of the echo profile to remove noise, multiple profile-averaging etc.

The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signal due to heavy dust or fill-stream interference.

In very dusty applications or in silo/ bunker, etc. filling applications, high power and long range (i.e., low frequency) transducer shall be used to overcome the detrimental effect of the dust. This type of instrument shall not be used for level measurement in process medium consisting of particles of sizes (- 6 mm diameter).

Ultrasonic transmitter shall be have 4-20mA (24V DC loop powered) / Field bus compatible and possible to calibrate through hand held universal and field bus configurator also.

The sensor shall have in-built temperature sensor for ambient temperature compensation.

Chemical compatibility of the sensor material with the process material shall be ensured, to avoid corrosion.

In applications, where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e. repetitive, pulsating displacement at its face shall be used to remove the material build-up).

Ultrasonic transmitters shall be supplied along with necessary calibration software, noise suppression software, plug connector, cable, profibus to RS232C modem etc. for calibration/ noise suppression through laptop / desktop PC.

Adjustable mounting arrangement shall be provided for proper aiming of ultrasonic sensors. Suitable protection box for ultrasonic level sensor shall be provided.

Provision for the nitrogen purging facility in the ultrasonic sensor shall be provided for cleaning the buildup of the material.

Pipe insert of min. dia 200mm shall be available for mounting the level transmitter on top of the tanks. Necessary mounting brackets for mounting the level transmitter in the tank shall be provided.

Range:	0 to 15 meters
Temperature:	-20 to +60° C
Temperature compensation:	Built-in -20 to +60° C
Spread:	3°, 6°
Enclosure:	IP 68 / NEMA 6P (submersible to 10 m / 30 ft. of water)
Measuring accuracy:	Better than 0.2%
Analog output:	Active 4-20mA galvanically isolated, max. loop resistance 500 Ohms
Digital output:	Two SPDT electromechanical relays. (max 50V DC / 1 A)
Transmitter Enclosure rating:	IP 65 / NEMA 4X

vi. Electromagnetic flow meter:

Selection of Electromagnetic flow meters shall be decided based on the following:

All magnetic flow meters shall be SMART type. Magnetic flow meters, which are to be installed in the control, alarm & interlocking circuits, shall have 4-20mA DC output (24V DC loop powered) / profibus compatibility along with Data loggers and battery back up.

Liner material shall be selected based on service. Generally, for liner material PTFE shall be used.

If gases are entrained in the liquid, meter shall be installed in vertical process line.

While installation it shall be ensured that flow tube is always completely filled with liquid.

Straight length requirement of minimum 5D to 10D in the upstream and 2D to 3D in the downstream shall be provided for water services. However, for other services it shall be designed as per manufacturer's recommendation.

The tube material shall be SS 316, with PTFE linner and SS-316 Electrode. The coil housing should also be of SS-316.

Installation of electromagnetic flow meters shall be avoided near large conducting surface e.g. metal surfaces. (Large surface may interfere with magnetic field of instrument thus affecting accuracy).

Pulsed DC excitation shall be provided for field excitation of Electro Magnetic Flow Meter. Power & signal circuits of magnetic flow meter shall be completely isolated from each other.

Minimum one no. of grounding ring for metallic pipelines and minimum two nos. of grounding rings for non-metallic pipelines shall be used for installing the magnetic flow meter.

Selection and sizing of electro-magnetic flow meters flow characteristics published by the manufacturers shall be followed. Allowable flow velocity shall be considered based on the specific merit of the service, allowable pressure drop, and cost effectiveness and as per manufacturers recommendation, however the size of flow meter shall not be less than the size of conduit where it is proposed.

Accuracy of magnetic flow meter shall be ± 0.3% or better. Local display shall be calibrated in engineering unit.

A bypass line with isolation valves shall be provided for the magnetic flow meters so that magnetic flow meters can be cleaned on line.

Sensor & transmitter of magnetic flow meters shall be mounted separately.

Magnetic flow meter shall be provided with built-in auto zero facility for ensuring stable zero point.

Separate earth pit shall be provided exclusively for earthing of magnetic flow meters. Preparation of such earth pits shall be governed by the general methodology as described in IS 3043, 1991 or relevant international standards.

Necessary calibration unit for checking the electronic unit of magnetic flow meter shall be provided.

Enclosure class of magnetic flow meters shall be IP 68.

Pulsed DC excitation for better accuracy and measurement signal stability shall be used. Power & signal circuits of magnetic flow meters shall be completely isolated from each other.

While installation, it shall be ensured that flow tube is always completely filled with liquid and at no time the flow meter shall be empty.

Flow meter shall be provided with necessary ground ring, fasteners, gaskets, reducer / expander, matching flange including straight line pipes (Inlet run: 5D min & Outlet run: 3D min / as per manufacturer recommendation). Also spool pieces of length flange to flange for replacing the flow meters during maintenance shall be provided.

Pressure data logger capable of transferring data via GPRS/SMS communication. Input pressure range of 0 - 20 bars, accuracy ± 0.5%, and repeatability ± 0.1%, with re-zero function for offsetting. Memory must be not less than 50,000 readings, and can be set in cyclic or start-stop (block). Logging interval can be set 1 second, 1 min, 15mins, 30mins, hourly etc. Capable to export data to comma-separated values (csv) file format or Excel spreadsheets. Software Supports statistical data (average, maximum, mean and standard deviations). Ingress Protection rating of IP68, with minimum battery life of 5 years.

Data loggers must be compatible with the Employer's telemetry software

Mounting: Flange

Materials: Housing: Painted carbon or stainless steel

Liner: Hard rubber, soft rubber or PTFE

Electrode: Stainless steel 1.4571

Built-in grounding electrode: required

Accuracy: Better than ± 0.25%

Temperature: 0 to 50° C

Enclosure: IP 67 (with gel potting IP 68)

Analog output: One active 4 - 20 mA, galvanic isolated (max. 800 Ω)

Digital output: One voltage-free, electromechanical relay (max. 50 V DC / 1 A)

One optically isolated (max. 50 V AC / V DC / 120 mA)

Transmitter Enclosure rating: IP 67

Power supply: 24 V AC

Data logger: Display 160,000 logs with date, time, value and daily totals

vii. Communication and Data Presentation/ Display

The controller should be interfaced with a GSM/GPRS communication modem to seamlessly transmit the data from remote plants to a central location over a pre-defined interval.

The communication to the system should be two way for ability to view settings and make changes to the configuration over the air, as and when required.

The data should be received at a central location and should be displayed there in real-time in graphical and tabular format. The software as a minimum should have ability to print reports, archive data and make it available for export as a CSV file. The system should also have facility to generate alarm when set points are exceeded

7.35 PARTICULAR TECHNICAL REQUIREMENTS - PIPE LINE WORKS

7.35.1 High Density Polyethylene Pipes (HDPE Pipes) Scope

This specification covers the requirements for successfully designing, manufacturing, supplying, laying, jointing and testing at works and site of High Density Polyethylene Pipes used for water supply.

7.35.2 Applicable Codes

The manufacturing, testing, supplying, laying, jointing and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In Particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

Others Codes not specifically mentioned here but pertaining to the use of HDPE pipes form part of these Specifications.

IS: 4984	High Density Polyethylene Pipes for Water Supply
IS: 2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS: 5382	Rubber sealing rings for gas mains, water mains and sewers. Methods for random sampling
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 7634	Laying & Jointing of Polyethylene (HDPE) Pipes
IS: 9845	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs
IS: 10141	Positive lists of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
IS: 10146	Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water.
IS 4905 1968	Methods for random sampling
IS 8360 (part- I): 1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – General Requirements"
IS 8360 (part- II) :1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Tee"
IS 8360 (part- III) :1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Bends"
IS 8008 (part-I): 2003	"Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies –Specification – General Requirements for fittings"

7.35.3 Designation

Pipes shall be designated as per IS 4984, according to the grade of material, followed by pressure rating and nominal diameter, for example, PE 100 PN 10 DN 200 indicates a pipe pertaining to material grade 100 having a pressure rating 1.0 MPa and outside nominal diameter 200 mm.

7.35.4 Colour

- For the purpose of identification of the pipes, each pipe shall contain minimum three equispaced longitudinal strips of width 3mm (min) in blue colour, these strips shall be coextruded during pipe manufacturing and shall not be more than 0.2 mm in depth. The material of the strip shall be of the same type of resin.
- All HDPE Pipes of the same size, same pressure rating and same grade and also manufacture essentially under similar conditions of manufacture, shall constitute a lot.

7.35.5 Materials

The material used for the manufacturer of pipes should not constitute toxicity hazard, should not support microbial growth, should not give rise to unpleasant taste or odor, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any internationally reputed organization as per the satisfaction of the engineer in charge.

7.35.6 Raw Material

Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427 for this a certification has to be given by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the following norms as per ISO 9080

(a) The resin should have been certified by an independent laboratory of international repute for having passed 10,000 hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10MPa. Internal certificate of any resin manufacturer will not be acceptable.

(b) Certificate for having passed the full scale rapid crack propagation test as per ISO 13478. High density Polyethylene (HDPE) used for the manufacture of pipes shall conform to designation PEEWA-45-T-006 of IS 7328. HDPE conforming to designation PEEWA-45- T-012 of IS 7328 may also be used with the exception that melt flow rate (MFR) shall not exceed 1.10 g/10 min. In addition the material shall also conform to clause 5.6.2 of IS 7328.

(c) The specified base density shall be between 941.0kg/ m^3 and 946.0kg/ m^3 (both inclusive) when determined at 27°C according to procedure prescribed in IS7328 The value of the density shall also not differ from the nominal value by more than 3 kg/ m^3 as per 5.2.1.1 of IS 7328. The MFR of the material shall be between 0.41 and 1.10 (both inclusive) when tested at 190°C with nominal load of 5 kgf as determined by method prescribed in IS 2530. The MFR of the material shall also be within ± 20 percent of the value declared by the manufacturer.

(d) The resin shall be compounded with carbon black. The carbon black content in the material shall be within 2.5 ±0.5% and the dispersion of carbon black shall be satisfactory when tested as per IS 2530.

7.35.7 Anti-oxidant

The percentage of anti-oxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harm less and shall be selected from the list given in IS 10141

7.35.8 Reworked Material

No addition of Reworked/ Recycled Material from the manufacturer's own rework material resulting from the manufacture of pipes is permissible and the vendor is required to use only 100% virgin resin compound.

7.35.9 Effect of nature of soil on pipe performance

The bidder shall provide certified information, as per IS code of practice about the performance of HDPE pipes, if laid in corrosive soils, below water table or under saturated conditions or rocky strata, etc. The necessary precautions, as per IS code of practice, to be taken like painting or bitumen coating or providing special bedding or crossing any feature under hanging, etc to encounter such conditions shall be mentioned and accounted for in the bid cost by the bidder

7.35.10 Maximum Ovality of Pipe

The outside diameter of pipes, tolerance on the same and ovality of pipe shall be as given in table 2 of IS 4984. Ovality shall be measured as the difference between maximum outside diameter and minimum outside diameter measured at the same cross section of the pipe, at 300 mm away from the cut end. For pipes to be coiled the ovality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipes shall be carried out prior to the measurement of ovality.

7.35.11 Wall Thickness

The minimum & maximum wall thickness of pipe for the three grades of materials, namely PE63, PE80, and PE100 shall be as given in table 3, 4, & 5 respectively in IS:4984.

7.35.12 Length of Straight Pipe

The length of straight pipe used shall be more than 6 m or as agreed by engineer in charge. Short lengths of 3 meter (minimum) up to a maximum of 10% of the total supply may be permitted.

7.35.13 Coiling

The pipes supplied in coils shall be coiled on drums of minimum diameter of 25 times the nominal diameter of the pipe ensuring that kinking of pipe is prevented. Pipe beyond 110mm dia shall be supplied in straight length not less than 6m.

7.35.14 Workmanship / Appearance

Pipes shall be free from all defect including indentations, delaminating, bubbles, pinholes, cracks, pits, blisters, foreign inclusions that due to their nature degree or extent detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in colour opacity, density and other physical properties as per relevant IS Code or equivalent International Code. The inside surface of each pipe shall be free of scouring, cavities, bulges, dents, ridges and other defects that result in a variation of inside diameter from that obtained on adjacent unaffected portions of the surface. The pipe ends shall be cut clearly and square to the axis of the pipe.

7.35.15 Marking of Pipes

The internal and outer diameter, length, wall thickness, tolerances and other dimensions of pipes shall be as per relevant clauses of IS 4984:1995 (inc. all amendments) and any amendments made to till date. Each straight length of pipe shall be clearly marked and should cover the following:

a. The manufacturers name and trade mark,

b. Outside diameter,

c. IS classification,

d. Stiffness class

e. Lot number / Batch number

7.35.16 Handling, Transportation Storage and Lowering of pipes

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole.

The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60°C.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.
- PE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks be used on PE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so permitted by the competent authority before installation.
- During coiling care should be taken to maintain the coil diameter at or above the specified minimum to prevent kinks. Coiling shall be done when the pipe attains the ambient temperature from the extruder. In uncoiling or recoiling care should be taken that sharp objects do not scour the pipe.
- When releasing coils, it must be remembered that the coil is under tension and must be released in a controlled manner. The end of the coil should be retained at all times, then the straps released steadily, one at a time. If the coil has bands at different layers of the coil, then they should be released sequentially starting from the outer layers. The amount of the energy locked up in the coil will depend on the size of the pipe, the SDR of the pipe, and the size of the coil.
- Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set
- Bare coils shall be wrapped with hessian cloth for long distance (> 300Kms) transportation. The truck used for transportation of the PE pipes shall be exclusively used of PE pipes only with no other material loaded – especially no metallic, glass and wooden items. The truck shall not have sharp edges that can damage the Pipe.

- Pipes manufactured at factory are to be carried to the site of work directly or stacked suitably and neatly along the alignment/road side/elsewhere near by the work site or as directed by the Engineer.
- Damages during transit, handling, storage will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost as directed by the Engineer.

7.35.17 Lowering, Laying of Pipes

Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Engineer shall be laid. While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same a backfill material. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M15, 15 cm or 20cm thick sand bed as approved by the engineer may be provided

As PE pipes are flexible, long lengths of fusion-jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets.During the pipe laying of continuous fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc) and at branch connections.

Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day). For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom. The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.

The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.

The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.

Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint.

PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done. When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern.

However, weights by way of concrete blocks (anchors) are to be provided so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away. Thus site conditions study is necessary to ensure the avoidance of flotation.

Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% maximum dry density.

7.35.18 Jointing of Pipes

The pipe shall have a jointing system that shall provide for fluid tightness for the intended service conditions. Appropriate jointing for HDPE pipe as per IS 4984 shall be selected considering site and working condition, pressure and flow of liquids.

i. All joints shall be made as per relevant IS code, in practice, and manufacturer's installation manual or instructions. All joints shall be tested for their performance as per provisions made in relevant IS codes. Joints that show leakage will not be accepted. After backfilling and inspection, if groundwater infiltration is observed through joints into the laid water line, then such joints shall be sealed by the bidder at no extra cost to the owner.

ii. Pipe surfaces to be joined must be free of dust, dirt, oil, moisture and other foreign material. If required, use of chemical such as dichloro-methane, methyl ethyl-ketone or mechanical cleaner may be carried out.

iii. Jointing of pipes and fittings shall be done by Electro fusion/ Butt fusion welding to joint two ends of HDPE pipes. ISO 12176-1:1998 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 1: Butt fusion and ISO 12176-2:2000Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 2: Electrofusion shall be followed for the same.

iv. However to join HDPE with other pipe/valves flanges/ mechanical joint compression fittings shall be used confirming to ISO 14236:2000 Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems

7.35.19 Bedding, Backfilling and Compaction

7.35.19.1 Bedding

In case of sandy strata no separate bedding is required. However the bottom face / trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe.

7.35.19.2 Back Filling

Backfilling should be placed in layers not exceeding 15cm thickness per layer, and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth fill on each side should not be more to cause lateral movement of pipe.

Most coarse grained soil are acceptable. This may comprise of gravel or sand.However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.

It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented.

Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

7.35.19.3 Compaction

Vibratory methods should be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe should be usually done with hand tempers. The backfill material should be compacted not less than 95% of maximum dry density.

7.35.20 Fittings & Specials

Injection moulded HDPE fittings shall be as per IS: 8008 (Part I to IX). All fittings/specials shall be injection moulded at factory only. General requirement of Injection moulded HDPE fittings conforming to IS: 8008 Part I.

Bends

HDPE bends shall be conforming to IS: 8008 Part II Specifications.

Tees

HDPE Tees shall be conforming to IS: 8008 Part III Specifications.

Reducers

HDPE Reducers shall be conforming to IS: 8008 Part IV Specifications.

Flanged HDPE Pipe Ends

HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VI Specifications. Stub ends will be welded on the pipe. Flange will be of slip on flange type as described below:

Slip-On Flanges

Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN10.

7.35.21 Welding Procedure

Jointing between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with fusion welding using automatic or semi automatic, hydraulically operated, superior quality fusion machines which will ensure good quality fusion welding of HDPE pipes. If approved by the concerned Engineer, jointing with PP compression fittings may be carried out for smaller diameters of PE pipes (up to 110mm).

7.35.22 Tests to Establish Portability of Work

Pipe specimen shall be subjected to tests specified below in order to establish the suitability of these pipes for use in carrying potable water:

I. Smell of the extract
II. Clarity of the colour of the extract
III. Acidity and alkality

IV. Global migration UV absorbing material Heavy metals

V. Un-reacted monomers (styrens) and Biological tests

7.35.23 Hydraulic Testing

Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per relevant IS and specification mentioned elsewhere in the bid documents. Hydro pressure testing shall be done on the completed pipe length for a minimum pressure of 1.5 times the designed pressure for retaining period of 4 hours, and as mentioned in IS 4984 –1995 including its latest amendments. The acceptance criteria for hydrostatic test are no permanent deformation of any part of the pipeline fitting or equipment's and there shall not be any leakage through any of the joints

7.35.24 Measurement

The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and measured and paid separately under the relevant item. The portion of the pipe at the joints (inside the joints) shall not be included in the length of pipe work. Excavation, refilling, masonry and concrete work wherever required shall be measured and paid for separately under relevant items of work.

Payment shall be made as per relevant items in BOQ

7.35.25 Rate

The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/enumerated separately under clause Measurements', which shall be paid for separately.

7.35.26 JOINTING MATERIAL: Detachable Joints

PUSH-ON JOINTS

For Push-on joints the rubber ring will be inserted through the chamfered spigot end of the pipe. The two pipes shall be aligned properly in the trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot.

After insertion, the correct position of the socket has to be tested with a feeler blade. A penetration gauge shall be used to check each joint after assembly, to ensure that the rubber ring is properly seated.

When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as per the instructions of the manufacturer and approved by the Engineer. It is important that in making the joint the pipes are maintained in a straight line and the deflection introduced after the joint has been assembled. However, it is preferable that such deflection will not exceed 75% of the permissible deflection at a single joint as stipulated by the manufacturer of the pipe.

7.35.27 MECHANICAL JOINTS

Bolts shall be tightened alternately on opposite ends of joint diameter and in rotation around the pipe. When properly assembled the gland shall be equidistant from the socket face at all joints. Under no conditions shall extension wrenches or pipe-over-handle or ordinary ratchet wrenches be used to secure greater leverage.

7.35.28 FLANGED JOINTS

Flanged joint pipes and fittings shall be firmly and fully bolted with machine bolts provided by the manufacturer. Standard flange drilling of flanged pipes and fittings shall be in accordance with IS: 1538. The nuts and bolts to be used for jointing shall be made of MS for size up to 27 x 120 mm and high tensile steel of approved make for higher sizes. Gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber of thickness between 2.5 mm to 3 mm in conformity with IS:3114. The fiber board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per sqm shall not be less than 12 gram/mm thickness.

Slip-on flanges shall be double welded to the pipe with a strength weld jointing the flange hub to the pipe and seal fillet weld inside the flanges at the pipe end. All flanges of the same diameter shall be compatible.

7.35.29 MS PIPE - TO BE USED FOR ENCASING AT ROAD / RAILWAY CROSSING ONLY

Providing, fabricating, testing, painting, supplying and installation of M.S. Pipes & Specials of specified ID / OD & specified wall thickness conforming to IS 3589-2001. Pipes shall be flanged with slip-on-boss flanged available open confirming to IS 6392-1971.

Pipes shall be made from steel plates conforming to relevant IS 2062 grade Fe410 or strips by butt welding longitudinally or spirally. The weld shall be continuous. Prior to welding, edges of plates or strips may be prepared suitably where required by the process of manufacture. Thickness of pipe shall be as per relevant IS specifications.

7.35.30 TOLERANCE

The tolerance on the pipe body shall be + 0.75 % for all sizes of pipes.

The tolerance on specified wall thickness shall be - 2% / + 10%

Straightness - Finished pipe shall not deviate from straightness by more than 0.2% of the total length. Checking shall be carried out using a taut string or wire from end to end along the side of the pipe to measure the greatest deviation.

Length - Straight pipe shall not vary from the specified overall length by +10 mm or -10 mm for length up to and including 6 m.

7.35.31 INSIDE / OUTSIDE COATINGS

The coating of the pipes shall be smooth, dense and hard. The coating shall be free from excessive surface irregularities. Projection exceeding 3 mm. measured from the general surface shall be removed. For inside coating of epoxy paint, the inside surface of the pipe should be sand or shot blasted. The surface should be thoroughly rubbed down with rough sand paper or wire brush so that surface will be uniformly rough. Mixed paint should be used within 3 to 4 hours of mixing and fresh mixing is taken for every new application.

Zinc rich epoxy primer and epoxy paint of approved quality shall be used for external and internal painting. No primer shall be applied without prior approval of the owner. The mix of zinc rich epoxy primer shall be prepared at works site not earlier than 15 min. before applying the same on pipes and special surfaces. One coat of zinc rich epoxy primer shall be applied along with 2 coats of epoxy paint. No thinner shall be added to ready mix paints without previous approval of the owner and the finishing coats on top of the primer coat shall only be applied after allowing the film to cure for at-least 48 hours.

After application of zinc rich epoxy primer, the surface should be cleaned by duster and inspected. If during inspection any portion is found rusting the same shall be removed by emery paper and coated with zinc rich epoxy primer.

7.35.32 STEEL FLANGES

The flanges and their dimensions of drilling, wherever not specified, shall be in accordance with IS:6392 – 1971 or its latest revision. The flanges shall be slip on boss type of 1N/mm^2 pressure rating. Prior to welding flange, the contractor shall have to obtain approval of Engineer for all sizes and types of flange drawings.

TESTS

All MS pipes shall be tested at recommended pressure.

REPAIR OF COATING AND LININGS

Any pipe with lining that is broken, defective, or not adhering in all places to the metal interior of the pipe, or not otherwise in accordance with the specification shall be rejected. Remedial lining operations may be carried out by a method as recommended by the manufacturer and has been approved in writing by the Engineer. The standard of the remedial lining shall satisfy the requirements of the specification.

Damage to external coatings shall be made good equivalent to the original coatings applied by the manufacturer and to the satisfaction of the Engineer.

Exposed surfaces shall be finish painted according to the manufacturer's instructions, and as directed by the Engineer, using a corrosion resistant paint.

7.35.33 Reinforced Cement Concrete Pipes

7.35.34 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS:458.

7.35.35 Manufacturing

7.35.35.1 General

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

For sewerage RCC pipes shall be internally lined with PE of min. 2.5 mm thk. The lining shall be guaranteed by fusing each individual pipe liner with the next for continuity and long life.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Engineer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Employers Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Employers Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

7.35.35.2 Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Employers Engineer before carrying to sites.

7.35.35.3 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

7.35.35.4 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

7.35.35.5 Mixing and Curing Water

Water shall be clean, colourless and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

7.35.35.6 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS: 432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS: 458.

7.35.35.7 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

7.35.35.8 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

7.35.35.9 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

7.35.36 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding. The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

7.35.37 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458. Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer, the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS: 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test
ii) Three edge bearing test
iii) Absorption test
iv) Visual Examination

7.35.38 Sampling and Inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of the Employer's Engineer shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS: 458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS: 458 if the following conditions are satisfied.

- The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.
- All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

7.35.39 Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe
b) Class of pipe
c) Date of manufacture and
d) Name of manufacturer or his registered trade-mark or both.

7.35.40 Jointing

7.35.40.1 General

Jointing of RCC pipes shall be done as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

7.35.40.2 Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

7.35.40.3 Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar hall then be placed symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45^0 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Employers Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

7.35.40.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

7.35.40.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

7.35.40.6 Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

7.35.40.7 Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

7.35.40.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance.

The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of the tender requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

7.35.41 Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole chamber to manhole chamber or for a stretch as directed by the Employers Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Employers Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Employers Engineer.

It shall also be ascertained by contractor that each stretch from manhole chamber to manhole chamber or the stretch as directed by Employers Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

7.35.42 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirement and as directed by the Employers Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Employers Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Employers Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Employers Engineer. Contractor if required by the Employers Engineer shall

dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work shall be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

7.35.43 UNPLASTICIZED POLY VINYL CHLORIDE (PVC-U) PIPES:

7.35.44 Applicable Codes

The manufacturing, testing, supplying and testing at work sites of PVC-U pipes shall comply with IS 15328:2003 and all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern:

Code No.	Title/Specification
IS 4905:1968	Methods for random sampling.
IS 4985:2000	Unplasticized PVC pipes for potable water supplies — Specification *(third revision)*.
IS 5382:1985	Specification for rubber sealing rings for gas mains, water mains and sewers *(first revision)*.
IS 12235	Methods of test for unplasticized PVC pipes for potable water supplies:
(Part 1): 1986	Method of measurement of outside diameter.
(Part 5):1986	Reversion test
(Part 8):1986	Internal hydrostatic pressure test
IS 14182:1994	Solvent cement for use with unplasticized polyvinyl chloride pipe and fittings — Specification
IS 15328:2003	Unplasticized non-pressure polyvinyl chloride (PVC-U) pipes for use in underground drainage and sewerage systems— Specification

Others Codes not specifically mentioned here but pertaining to the use of PVC-U pipes form part of these Specifications.

7.35.45 MARKING

Each pipe shall be clearly and indelibly marked in ink/ paint or hot embossed on white base at intervals of not more than 3 m, but at least once per pipe, in the colour differs from the basic colour of the pipe. The marking shall be legible without magnification. The marking shall not initiate cracks or other types of defects which adversely influence the performance of the pipe. Marking by indentation reducing the wall thickness not more than 0.15 mm shall be deemed to conform to this clause without infringing the requirements for the wall thickness given in 6.1.2. of IS 15328. The markings shall include the following:

a) Identification of the source of manufacture or trade-mark,
b) The nominal pipe diameter,
c) Stiffness class of pipe,
d) Insertion depth of end for joint to be marked on perimeter of pipe on both the ends by 10 mm thick red colour.
e) Batch No. /Lot No. or date of manufacture.

7.35.46 Inspection and testing:

The material will be inspected and tested by the third party Inspectors to be nominated by the Employer. The sampling procedure to be adopted and the criteria for conformity shall be as given in Annex F of IS: 15328.

a) Physical Dimensions and visual inspection: The Manufacturers test reports shall be provided for review.

b) Vicat Softening temperature shall be carried out as per Annex A of IS 15328.

c) Ring Stiffness shall be as per IS 15328.

d) Resistance to Internal Hydrostatic pressure shall meet the requirements of IS 15328.

7.35.47 Joints

Elastomeric sealing rings shall be free from substances (for example, plasticizers) that can have a detrimental effect on the polyvinyl chloride of the pipes or fittings used in conjunction with the pipes.

The design of the profile and dimensions of the sealing ring is left to the manufacturer, as long as the pipe with the sealing ring meets the requirements of this standard. Where the design of the socket is such that the sealing ring is not firmly fixed in position, the housing for the ring shall be so designed as to minimize the possibility of the ring being dislodged during insertion of the pipe (or spigot of a fitting) to complete the joint.

Elastomeric sealing rings shall be in accordance with one of the types (Type 1 to Type 6) of IS 5382. The manufacturer has to, however, specify the type of sealing ring (namely Type 1, 2, 3, 4, 5 or 6) that is being offered.

7.35.48 LAYING AND JOINTING OF SEWERS

All the sewer lines are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe, the socket end of the pipe shall face upstream.

The sewer lines shall be laid such that the marking on pipes appears at the top of the pipes.

Properly fitted temporary wooden stoppers shall be provided to close the ends of all incomplete sewer line. The stoppers are only to be removed when pipes are being laid and jointed. Opening of sewer at end of day's work shall be capped and sealed.

Sewer pipe laying and jointing shall be started and completed only section wise as per the instruction of the Project Engineer. The sections shall be chosen manhole chamber to manhole chamber. However in unavoidable circumstances the section of sewer line shall be changed as per site condition & as directed by Project Engineer. The work of sewer line laying, manhole chamber construction and house sewer connections shall be done simultaneously so that all the necessary testing can be done efficiently.

After laying of pipe line the trench shall be filled up to top of pipe with moist soil. The trench can be filled up to the top of the pipe level with moist soil to ensure curing of concrete and then after testing of sewer line, trench should be filled. In the duration before filling the trench, soil should be kept moist to ensure adequate curing.

The sewer lines shall be secured in place with approved backfill material tamped under it and proper care shall be taken during tamping at the socket end of the pipe to check that it is not damaged. The watering shall be done on the refilled material in the trench before compaction based on the OMC of the soil to achieve 90 % MDD of the refilled material.

Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings shall be made by Contractor at his own cost. In no case pipes and fittings shall be dropped.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and Engineer gives permission to proceed with the backfilling.

The pipes fittings and other construction material shall be placed along the alignment in advance with utmost care during transit so that they are not damaged. Any damage due to these reasons shall be Contractor's liability.

7.35.49 Laying and jointing of sewers lines by Trenchless Technology

All the sewer lines are to be laid perfectly true both in alignment and to gradient specified. The designed levels and the gradient shall be achieved. The work shall be carried out in trench less technology by suitable method. The contractor shall propose the details and methodology for the carrying out the laying of the pipes through trench less and get the approval of the proposed methodology from Project Engineer prior to start of work.

7.35.50 Bedding

For RCC pipes bedding shall be designed taking into account the required external loading conditions, geotechnical requirements such as sub soil and bearing capacity of soil encountered in respective sewer line, type, class and material of pipe used for the laying purposes as per CPHEEO manual.

All plastic pipes (uPVC / HDPE) pipes shall be provided with minimum 4 inches of uniform river natural graded sand bedding free from any foreign /sharp etc. The filling surrounding the pipe shall also be of uniform sand for at least 3 inches on each side and until 3 inch above crown of pipe. This shall be done to avoid any possibility of damage to plastic pipes during backfilling.

The bedding below the pipe line and backfilling shall be provided as per the standard / approved drawing / as per direction of the Engineer. After the work of laying and jointing of pipes is completed, the pipes line shall be subjected to hydraulic test at work site. The pipes line should be tested immediately after laying of pipe line. The water required for testing and for any other purpose shall be arranged by the Contractor at his own cost.

7.36 PARTICULAR TECHNICAL REQUIREMENTS – SEWER REHABILITATION WORKS

7.36.1 TERMINOLOGY AND GENERAL DESCRIPTIONS

For the purpose of this project, some of the technical terms pertaining to the rehabilitation works and their functional details are defined below. The definitions herein are meant only as a guide and some of them are reproduced from Trenchless Technology Guidelines, published by ISST, UK. If other (or new) definitions or technical terms are used by the Contractor in his submittals, they shall be clearly defined by him in the submittals.

i. Rehabilitation of Sewers

For the purpose of this specification, Rehabilitation of Sewers is defined as a process of improving or restoring the structural and hydraulic performance capacity of the sewers by permanently incorporating a fabric of lining materials to the inner sewer body of the sewers by trenchless or other methods.

ii. Trenchless Technology

A technological process that requires less or no digging of ground surfaces to line, install, replace, renovate or repair underground utility pipes, ducts, cables and other conduits. This also includes other associated processes such as underground inspection and mapping of utilities and, their structural conditions, cavities, geotechnical and geological features etc., without opening up or digging of ground surfaces.

iii. Confined Space

“Confined space”, in relation to a place of work, means a space of any volume which a person may at any time enter or be allowed to be enter in which the atmosphere is liable at any time to be oxygen deficient. This includes but not limited to pipes, sewers, manhole chambers, tunnels, shafts, ducts, other similar sewerage installations and etc.

iv. Trenching or Open Excavation

It is a process of temporarily opening up of ground surfaces for the purpose of installation, replacement, renovation and inspection of underground utility pipes, ducts, cables and other conduits.

v. CCTV Inspection

Close Circuit Television Inspection is a process of carrying out internal inspection and surveys of pipelines using a self-propelled and remote controlled television camera system.

vi. Host Pipe

The original pipe to which the liner is installed.

vii. Man Entry

Description applied to any trenchless process, which requires an operator to enter a pipeline, duct or bore. The minimum size for which this is permissible may be defined by local legislation. For the purpose of this specification the man entry size is specified as the internal pipe diameter is greater or equal to 1000 mm.

viii. Fully Deteriorated

For the purpose of this specification, the fully deteriorated sewer is considered as one that has lost its load carrying capacity and collapsed at certain sections and shows signs of total collapse if no attempt is made to restore its structural capacity to bear the full load from ground, traffic and ground water.

ix. Partially Deteriorated

Similarly, the partially deteriorated sewer is considered as one that shows signs of deterioration of structural capacity and is likely to collapse in the foreseeable future, if no attempt is made to stop further deterioration and restoration of its structural capacity to bear the full load from ground, traffic ground water.

x. Intact Pipe

The existing sewer body is in good condition and is capable of carrying the externally imposed earth pressure and traffic loading but has lost its water tightness and ability to withstand the hydrostatic pressure.

xi. Preconditioning Work

That part of a project, usually before renovation work, which includes Preparatory Cleaning and Internal inspection.

xii. Ovality

The difference between the mean inside diameter and minimum inside diameter divided by the mean inside diameter at any cross section of a pipeline, generally expressed as a percentage.

xiii. Patch Repair

A type of Localised Repair in which a short sleeve of resin impregnated material is positioned within the defective carrier pipe and cured.

xiv. Live Insertion

Installation of a liner into a pipeline, whilst it remains in service also referred to as On-Line Renovation.

xv. Localised Repair

Repair work on a pipeline, particularly a sewer, for lengths less than the distance between two access points.

xvi. Grouting

Filling of the annular space between the host pipe and the new product pipe / Liner, Grouting is also used to fill the space around the laterals and between the new pipe and manhole chambers. Other uses of grouting are for Localised Repairs of defective pipes and ground improvement prior to excavation during new installations.

xvii. Close Fit Lining

A lining system in which the new pipe makes close contact with the defective carrier pipe. Typical techniques are those in which the liner is temporarily reduced in size by swaging or folding, and is reverted to its original size after insertion into the defective pipe (host pipe).

xviii. Cured-In-Place-Lining

A system in which a flexible, fabric tube is impregnated with resin and forced into position against the inner wall of a defective pipeline or other conduit before curing the resin to harden the

materials. The uncured lining may be installed by winch or inversion by water or air pressure. Linings may be structural or supplementary to the existing pipeline.

xix. Segmental Lining

The use of prefabricated segments in Man-Entry work to form a new lining within a defective carrier pipe. The segments are discrete pipes sealed at the joints and the annulus grout-filled to bond with the host pipe.

xx. Spiral Lining (SWL)

A technique in which a ribbed plastic strip is spirally (or helically) wound by a winding machine to form a liner which travels up the host pipe as further turns of the helix are added. The annular space may be grouted or the spiral liner expanded to reduce the annulus and form a Close-Fit Liner. In larger diameters the liner may be produced from within the host pipe by manually forming the plastic strip into a helix.

xxi. Slip Lining

Insertion of a new pipe by pulling or pushing it into the existing pipe, usually followed by grouting the annular space. The pipe used may be continuous or a string of discrete pipes. This latter is also referred to as segmental slip lining.

xxii. Soft Lining

An alternative term for Cured-in-Place Lining.

7.36.2 Information for the execution of works

Where specified in the Drawings and Bills of Quantities, sections of the sewer shall be rehabilitated by lining method as approved by the Engineer.

The contractor shall be responsible for inspecting the sites and familiarizing himself with the conditions under which the work will be performed and with all necessary details as to orderly execution of the work. The omission of any details shall not relieve the Contractor of full responsibility for the satisfactory installation of the work in its entirety. No monetary or other claims made by the Contractor on the grounds of want of knowledge will be entertained by the Employer.

The contractor is advised that it shall be deemed to be his sole responsibility to ascertain for himself the extent of work that is required to be done in site and to generally obtain his own information on all matters affecting the execution of the whole of the works involved in this contract to the entire satisfaction of the Engineer. No claim of extras in consequence of any alleged ignorance in any aspect will be entertained by the Engineer. It must be clearly and definitely understood that the contractor shall be held solely responsible for making all necessary arrangements and co-ordinating with all relevant Authorities, Specialists, Sub Contractors, etc. to ensure satisfactory completion of this contract.

7.36.3 Site investigation

The Contractors site investigation for lining work shall be critical and the most important engineering work to be carried out before commencement of lining work. The contractor shall clearly understand the importance of establishing the predominant subsurface ground conditions and their range of variability along the sewer route well before embarking on the actual lining works.

This shall include:

- Determination of water table and groundwater
- Determination of soil type and condition in sewer location.

The contractor shall carry out Geo Technical Investigation at every 1000 m interval of alignment of existing sewer, for determination of soil type, density, modulus of soil , water table and groundwater etc. for designing **Type II standalone structural Liner**.

The Contractor is deemed to have visited the sites and familiarised himself of the conditions, restrictions and constraints under which the work will be executed. The omission of any details shall not relieve the Contractor of his prima facie obligation and responsibility under the Contract to carry out and successfully complete the rehabilitation works. No monetary or other claims, made by the Contractor on the grounds of want of knowledge will be entertained by the Employer.

7.36.4 Safe Entry and Working in Sewers

The Contractor shall ensure that all the necessary safety requirements for persons working in sewers, manhole chambers, chambers, and all other sewerage installations are fully complied with all statutory safety requirements and provisions and the clauses in the specification.

7.36.5 Ventilation

The Contractor shall provide adequate ventilation and efficient apparatus to keep all excavations, tunnels and sewers free from all dangerous gases, and he shall take precaution to ascertain that they are in a safe condition before allowing his workmen to descend.

While working in existing sewer or manhole chamber, the Contractor shall provide air blowers to ventilate the place as sewage gas usually contains a high proportion of hydrogen sulphide, methane and other toxic gases which in combination with oxygen is explosive. Approved gas monitors/detectors and oxygen meters shall be used to ensure that the place is free from all dangerous gases.

The Contractor is required to appoint a supervisor to ascertain that the sewer or manhole chamber is in a safe condition before allowing his workmen to descend and work. No smoking or naked flame shall be allowed in the sewer or manhole chamber. Monitoring of the air quality shall also be carried out regularly by the Contractor's supervisor while work is in progress and work shall be immediately suspended should unsafe condition develop.

The Contractor is warned that besides performing any work in existing sewer or manhole chamber, connecting to or breaking into existing sewer or manhole chambers also poses potentially hazardous conditions. The existing sewer or manhole in which the work has to be carried out should therefore be thoroughly ventilated and certified as safe by the supervisor before workmen are allowed to execute the connection. During the work all the safety precautions shall be followed.

7.36.6 Sewer Rehabilitation Works-Procedure

7.36.6.1 Preparation Work

Sewer rehabilitation shall include all aspects of restoring the structural capacity and hydraulic performance of an existing sewer. The method employed in rehabilitation shall be by approved lining and local in-situ temporary repair of sewer and rehabilitation of manhole chambers.

The Contractor shall be responsible for locating and accessing all the required manhole chambers along the sewer lines to be rehabilitated. This also includes locating and reinstating of all property /house service connections and lateral connections to the sewer section being lined. Should a manhole chamber be buried, the Contractor shall notify the Engineer and he shall arrange for the manhole chamber to be exposed.

In all cases the Contractor shall endeavour to utilise existing manhole chambers for access, insertion and installation of rehabilitation systems. Working shafts may be sunk with the approval of the Engineer but will not be paid for. Alteration to existing manhole chambers for access, insertion and installation of rehabilitation systems may be allowed by the Engineer but no additional payment will be made for access arrangements made to or reinstatement of the manhole chamber.

Where services are encountered in the sinking of working shafts or trial trenches the Contractor will allow-in his rates for all temporary support or diversion in accordance with the utility service authority's requirements.

The Contractor shall allow for any difficulty and inconvenience to be encountered during the construction works. He is deemed to have visited the site pursuant to the relevant clauses in the Conditions of Contract to ascertain existing conditions and constraints of whatever nature, including the amount of sewage flows; the depth, size of sewers, material of sewer, length and condition of sewers and manhole chambers, and the nature of the ground conditions etc. relevant to the rehabilitation of the sewer lines included in the contract.

7.36.6.2 Preparation Prior to Sewer Rehabilitation

The Contractor shall be responsible for liaising with owners and/or occupiers of all properties affected by the works and for such means as are necessary to maintain sewerage services during the works. The Contractor shall submit details of the means to maintain sewerage facility to the Engineer for approval prior to commencement of work.

If required by the Engineer the sewer shall be checked for collapses immediately before rehabilitation by man entry inspection of sewers if a collapse is detected, its position shall be determined and the debris removed. The collapse shall be brought to the attention of the Engineer, and repair of the collapse shall be undertaken by the Contractor as per details to be approved by the Engineer. The Contractor shall then commence work on the next available sewer within two working days.

7.36.7 Proposed Sequence of Rehabilitation Work

Manhole chamber cleaning and Stanching

Installation of sufficient capacity Pumping Arrangement and flow diversion

Desilting of sewer

Sewer cleaning and colour CCTV inspection

Structural assessment and make recommendations on the appropriate local repair, measurement of internal dia., replacement work etc. if required, to be carried out before proceeding with lining work.

Upon completion of the above, the following shall be carried prior to lining:

- Submission of detailed liner design calculations and method statement and temporary structural enhancement work carried out.

- Carry out sewer lining works including QC (quality control) tests and appropriate safety measures.
- Reinstatement of laterals to re-lined sewers and re-lined sewers to existing manhole chambers.
- Final sewer cleaning and CCTV inspection
- Manhole chamber rehabilitation

It is deemed that the Contractor has allowed for in his prices in the Contract to carry out all the pre and post rehabilitation works, including the above generically described work, and also for everything else required to fulfil his prime obligation and responsibility to rehabilitate all the sewers included in the scope of work in accordance with the approved design, specifications and requirements as outlined in the Contract.

7.36.8 Sewer Inspection

The Contractor shall inspect each sewer for which re-lining is proposed to confirm or determine the following:

- That adequate access to the sewer is available at manhole chambers.
- The location of existing services whether shown on the drawings or not.
- The length of sewer to be relined.
- The number of lateral connections to the sewer and their locations and access to the lateral via inspection chambers.

a) The lining shall be a close fit against the original pipe / annular space between host pipe and liner shall be well grouted along the whole of its length and lateral connections shall be clean with no projections.
b) The lining shall be free from visible defects including foreign inclusions, dry spots, air bubbles, pinholes and pimples.

In the event that the lining is unacceptable due to partial collapse or due to an unacceptable degree of all type of defects etc., the Contractor shall remove and replace with a lining of the same thickness as the failed lining at his own cost. The Contractor shall submit to the Engineer for approval a complete method statement of these or any other remedial processes he proposes to use. All such remedial works of renovation, repair or replacement shall be carried out at no cost to Employer.

7.36.9 Flow Diversion

7.36.9.1 Bypass Pumping/Diversion of Flow

Sewerage services shall be maintained at all times during the works. Sewers to be inspected shall be kept at specified maximum depth of flow unless otherwise allowed by the Engineer.

The Contractor shall supply details to the Engineer, from whom prior approval should be sought; outlining his methodology for maintaining sewerage services through bypass pumping of upstream sewer in to the downstream sewer of the stretches which is under rehabilitation.

The contractor shall submit flow diversion proposal to the Engineer for approval. The proposal shall include details of plugging/ blocking of sewers and diversion arrangement either by pass pumping of

upstream flows.

The Contractor is deemed to have inspected the site and ascertain himself the availability of such bypassing opportunities in the vicinity of the sewer lines to be rehabilitated before pricing the Contract. He shall include all the expenses for controlling the flow during the rehabilitation works.

The Contractor is deemed to have included in his prices for plugging, deployment of requisite pumps, gen sets etc. for proper diversions/ bypass pumping of sewer.

The sewers are generally flowing full in the peak hours. The by-pass system shall be of sufficient capacity to handle the estimated flows and the wet weather flows during and after a rainstorm.

The Contractor shall note that it is entirely his responsibility to devise appropriate flow diversion strategies and to allow for their costs in the Contract. The above information on diversion possibilities is provided to assist the Contractor to devise appropriate flow diversion strategies and the Engineer does not take responsibility for its availability or applicability.

The Contractor must allow in his flow diversion strategy for possible backflow from pumping stations and inflow from storm water drains. Infiltration flow must also be allowed for sewers situated adjacent to drain.

7.36.9.2 Contractor to have Adequate Pumping Facilities

The Contractor shall satisfy himself that the pumping equipment he proposes to use is sufficient and adequate for all flows actually encountered in the sewers.

The Contractor shall retain on site sufficient standby pumping equipment to replace defective units in the event of a breakdown. A competent person approved by the Engineer shall attend to the pumping equipment at all times.

Approval of the Contractors proposals by the Engineer shall not relieve the Contractor of his responsibility to ensure that sufficient and adequate pumping arrangements are provided at all time and for all flows.

The Contractor shall in addition to all the foregoing requirements of this Clause also allow in his rates for the provision (including establishment and removal), operation, maintenance and noise suppression of all over pumping plant; for the provision (including establishment and removal), operation and maintenance of all delivery hose installed and for the period during which by pass pumping work is required; sinking hoses in trenches; backfilling and reinstating those trenches as required; placing horizontal and/or ramped metal plating over temporary diversion of the delivery hose either in trench or at the road surface and for routing delivery hoses through other conduits; standing and plugging lateral connections as well as other relevant requirements of the Engineer

7.36.10 Cleaning of Sewer Prior to Inspection

Sewers to be inspected shall be suitably cleaned by high pressure water jetting (the minimum pressure to be used shall be proposed by the Contractor and approved by the Engineer) to remove all silt, grease and loose material, to the satisfaction of the Engineer.

Where necessary mechanical cleaning tools may be used to scrape off grease and encrustations in the sewer prior to the final inspection.

Where necessary mechanical tools shall be used for the removal of boulders, tyres, steel, concrete

and any other items found in the sewers.

Due to limited access and the type of debris encountered, manual methods may be permitted by The Engineer. The Contractor shall include his intention for manual methods in his Work Method Statements.

All mass roots, intruding laterals and concrete shall be neatly cut off as required for proper structural lining work.

Cleaning shall be carried out from the upstream access manhole chamber to the downstream access manhole chamber and shall include all operations necessary to remove all silt, grease, loose material, boulders, concrete, steel, tyres and any other debris from the sewer bore and manhole chamber. All loosened and inherent silt and grease material in the pipeline shall be prevented from passing downstream.

The methodology for trapping all silt, grease, loose material, boulders, concrete steel tyres and any other debris from passing downstream shall be submitted to the Engineer for prior approval. Notwithstanding the approval of the Engineer, the Contractor shall ensure that the method or methods adopted shall be effective in the prevention of silt migration downstream.

All silt, grease, loose material, boulders, concrete, steel tyres and any other debris removed from the sewers and manhole chambers shall be disposed of in an environmentally acceptable manner at the approved disposal grounds.

The Contractor is required to provide equipment of the appropriate calibre to deal with the demanding service conditions, including heavy grease, deposits of silt, cement grout, concrete, tyres, other debris and high levels of infiltration that he can expect to encounter in the sewerage network without causing any structural disturbance to the body of the sewer. A combination of mechanical equipment and suction/ jetter unit or similar is recommended. Details of the proposed combination unit or units and including ancillary features (including root cutter) shall be provided to the Engineer for approval prior to commencement of clearing work. Notwithstanding the approval of the Engineer, the Contractor shall ensure that the equipment adopted shall be effective in cleaning sewers as specified.

7.36.11 Sewer- Cleaning Immediately Prior to Rehabilitation

Cleaning immediately prior to sewer rehabilitation shall include all operations necessary to remove all grease, slime and loose material from the sewer and manhole chambers and disposed of in an environmentally acceptable manner at approved disposal grounds. All loosened and inherent silt and grease material in the sewer to be rehabilitated shall be prevented from passing downstream.

The methodology for trapping all silt, grease, concrete, boulders, timber, steel, tyres and loose material from passing downstream shall be submitted to the Engineer for prior approval. Notwithstanding the approval of the Engineer the Contractor shall ensure that the method or methods adopted shall be effective in the prevention of silt migration downstream.

Sewers shall be suitably cleaned by mechanical means and high pressure water jetting, at a minimum pressure and flow rate (to be proposed by the Contractor and approved by the Engineer) to remove all silt, grease, concrete, boulders, timber, steel, tyres and loose material to the satisfaction of the Engineer.

Where necessary mechanical cleaning tools may be used to scrape off heavy grease deposits and

encrustations in the sewer with the prior approval of and as directed by the Engineer. The Contractor shall ensure that the removal of all silt and other undesirable materials on the surface of the sewer shall be such that the surface is conducive enough to make effective bonding in accordance with the design assumptions assumed by the Contractor in the structural design of the liner.

The adequacy of the cleaning work shall be monitored with CCTV/Video pan, tilt (and zoom) equipment and the Video tape shall be jointly viewed by the Contractor and the Engineer's staff to determine that the cleaning and any temporary repairs carried out are satisfactory.

The Contractor is required to provide equipment of the appropriate calibre to deal with the demanding service conditions, including heavy grease, silt, grease, concrete, boulders, timber, steel, tyres and other debris and high levels of infiltration that he can expect to encounter in the sewerage network. Details of the proposed methodology and equipment used shall be provided to the Engineer for approval prior to commencement of cleaning work.

Notwithstanding the approval of the Engineer the Contractor shall ensure that the equipment adopted shall be effective in cleaning sewers as specified without causing or precipitating (further) structural damage including collapse. The Contractor shall note those locations where the initial colour CCTV survey indicates the sewers to be in poor structural condition and shall ensure that cleaning operations cause no damage to the sewers at these locations.

Sewer rehabilitation shall not proceed without full compliance of above requirements and the approval of the Engineer after viewing the CCTV tape or inspection of the sewer as per the clause above.

Sewer rehabilitation shall be carried out within three (3) days of cleaning. If rehabilitation works are delayed for a period in excess of three (3) days after cleaning, the sewer shall be re-inspected and re-cleaned in accordance with the above clause, unless instructed otherwise by the Engineer. All costs associated with re-inspection and re-cleaning shall be borne by the Contractor.

The Contractor shall include in his rates for complying with the foregoing requirements of this clause.

7.36.12 Mass Roots, Intruding Laterals, Concrete Grout and Other Obstructions

(a) All mass roots, intruding laterals, concrete grout and other obstructions shall be neatly removed and the surface grinded to an acceptable finish. Other obstructions typically consist of, but are not restricted to, intrusion of steel bars, cables or timber etc. that are the result of construction or other activities, which result in the intrusion of such material through the sewer pipe. Care is to be taken to ensure that damage to the existing sewer body is minimised. All cutting/grinding activities are to be carried out under supervision.

(b) The scope of works for the removal of mass roots, intruding laterals and other obstructions shall include firstly the grinding down of the root, lateral intrusion or other obstructions until the surface of the sewer pipe at the point of entry of the root, intruding lateral or other obstructions is fully exposed. The exposed surface shall then be ground to a depth of two thirds the thickness of the pipe wall. The. Recessed surface and any cracks or openings shall then be prepared by steam cleaning or by high Pressure water jetting. All prepared surfaces shall then be filled by the injection of an epoxy repair material. The final surface shall be smoothened to provide a hydraulically smooth finish.

(c) The scope of works for the removal of concrete grout shall include the grinding down of the

concrete grout until the surface of the sewer pipe is fully exposed. The exposed surface shall then be filled with an epoxy repair material and the final surface shall be smoothened to provide a hydraulically smooth finish. All surfaces shall be prepared by steam cleaning or by high pressure water jetting before the application of the epoxy filling material.

The length of repair for each removal of mass roots, intruding laterals, concrete grout or other obstructions shall extend a minimum additional length of 100 mm around the defect to enable the provision of a smooth transition between the repaired surface and the host pipe.

7.36.13 Removal of Heavy Grease Deposit, Encrustations/Crystallised Deposits in Sewers

All heavy / thick grease deposits and encrustations that cannot otherwise be removed by high pressure water jetting, either during sewer pre-conditioning or sewer cleaning immediately prior to rehabilitation or at such times as directed by the Engineer, shall be removed by an approved mechanical means. The proposed method(s) shall include the removal of hardened heavy/thick grease deposits and encrustations and/or crystallised deposits found on the inner surface of sewers.

The contractor is deemed to have allowed for in his price for the Contract for all the above work.

7.36.14 Repair works prior to Lining & Sewer Rehabilitation works

7.36.14.1 Cleaning & Surface Preparation

The selection of equipment and methods used for the cleaning and surface preparation shall be the Contractor's responsibility.

All silt, debris and materials removed during cleaning shall be collected and extracted from the sewer at the next downstream access chamber.

Preliminary cleaning of the existing concrete surface shall be carried out by high pressure water washing to remove surface contaminants and concrete and mortar softened by acid attack.

For the brick sewer where significant mortar loss has occurred in the joints between bricks, precautionary measures shall be included in working procedures to account for the possibility that bricks may dislodge or come loose during cleaning and surface preparation.

7.36.14.2 Surface Preparation for TYPE II Linings

The Contractor shall thoroughly clean the inside of the existing sewer conduits to prepare them for installation of the lining.

All dislocated joints, stepped joints or other surface irregularities of the existing sewer pipes shall be made as smooth as possible by grinding and cement mortar/epoxy mortar as required.

This is required to ensure the maximum possible cross sectional area of the existing sewer is maintained at the joint.

It is also required so that the proposed liner shall fit the actual pipe cross section at either side of the joint without any damage caused by the dislocated joint or surface irregularity. It is also to ensure that there are no voids/gaps formed between the liner and the existing sewer pipe.

7.36.14.3 Inspection of Pipeline

All conduits shall be inspected to confirm they are cleaned and ready for installation of the lining. Visual inspection shall be carried out for all man-entry conduits.

7.36.14.4 Treatment of Exposed Reinforcement

Following cleaning of the pipe and prior to lining, any exposed reinforcement shall be inspected to determine if any action is required prior to lining.

For sewer pipe 1000mm diameter and less, if inspection indicates there is a risk of damage to the lining then a robotic cutter shall be used to remove the protruding sections of reinforcement.

For larger diameter conduits man access shall be used to wire brush clean and coat exposed reinforcement with a zinc rich epoxy primer.

Additionally for CIPP inverted lining systems, reinforcement shall be coated with a minimum thickness of 3 mm of epoxy mortar or cement render to avoid potential damage to the containment tube during installation.

7.36.14.5 Infiltration Control

Measures shall be instigated to limit or/control infiltration during lining to ensure that the completed lining is installed in accordance with the requirements of this specification.

For Type II standalone structural linings, infiltration shall be controlled during lining to prevent contamination of the grout, and to ensure complete filling of the annular space between the liner and the existing sewer.

The arrangement of reducing groundwater infiltration or any sullage from drains, dewatering techniques to lower the groundwater level may be required in some locations.

7.36.15 Structural Lining

The intent of rehabilitating the existing conduits by lining is, among other things, to

- Restore or increase the structural capacity of the sewer
- Protect the internal surface of the sewer from chemical and biological attack from a sewage environment in a tropical climate.
- Provide adequate abrasion resistance to the internal surface of the sewer to prevent structural degradation due to migration of silt, sand and debris and movement of cleansing equipment.
- Improve hydraulic performance and capacity of the sewer by using materials that offer least flow resistance.
- Seal all opened up and leaking joints and Provide complete water tightness to the sewer
- Prevent infiltration of groundwater and ex-filtration of sewage.

7.36.16 Types of Lining Systems

This specification is applicable for Type II standalone structural liner for the following lining systems and material types:

- Structural Lining with cured in place pipes (CIPP) formed using resin impregnated tubes for all sizes of pipes.
- GRP segmental liner
- Structural lining using Machine spiral wound technology.

Use of the systems mentioned above does not necessarily imply that they will satisfy the requirements of this specification. Type II Structural linings may for instance require strengthening by inclusion of special reinforcing layers and corrosion protection layers to satisfy design requirements of the specification.

7.36.17 Definition of Lining Types

7.36.17.1 Lining Type

For the purpose of this specification linings will be broadly classified into two categories. The classification is in accordance with the Water Research Centre's Sewer Rehabilitation Manual and is as follows:

Type I Lining: Linings that form a bond to the grout and/or the sewer wall, so that the renovated sewer acts as a rigid composite body.

Type II Lining: Lining is designed as a flexible pipe that does not rely on bond with the sewer wall. Structural capacity results from the self-strength of the lining and grout as a standalone liner and no long term strength is assigned to the existing sewer body.

7.36.18 General Design Requirements

(a) The liner must have sufficient strength to support all loadings.

(b) The liner must seal the sewer to prevent the infiltration of ground water into the sewer and the ex- filtration of sewage into the surrounding ground.

(c) The lining system must be proven technology for sewers of comparable size and shape and materials.

(d) The liner shall be designed to withstand all construction loads including handling, lifting, installation and grouting stresses without overstressing the liner or cracking

(e) The liner shall have protective layers on the interior or exterior surfaces to meet technical requirements in the specification.

(f) The internal surface of the install liner shall be smooth with Colebrook White roughness of not more than 1.5mm throughout its life span.

(g) The relining of the sewer shall be wrinkle free and retain the grade and level of the existing sewer.

(h) The internal surface of the liner at the joints shall be flush with a tolerance step of not more than 1mm between adjoining pipes.

(i) The joints shall be leak free and watertight and able to resist opening due to external or internal forces & structurally sound.

(j) Details shall be provided for the cutting and making good of the laterals and branches. Also to provide details of sealing grout holes for Engineer's approval.

(k) The design, manufacturing and delivery of the liner shall comply with ISO 9002 for production and delivery.

(l) All design calculations required as per the specification shall be supplied for Employer's approval.

(m) Grouting holes (at least 2 Nos. per panel/section) shall be provided in the liner at appropriate locations, as approved by the Engineer.

(n) The minimum thicknesses of grout for design purposes (refer Section 4.3.2 of WRc Manual, 4th Edition for thickness of grout) shall be 15mm.

7.36.19 Hydraulic Requirements

7.36.19.1 Reduction in the Cross Sectional Area

The liners are to be circular structural liners and must retain the largest possible internal dimensions (diameters). The reduction in the physical cross sectional area of the existing sewer lines after the rehabilitation shall be allowed up to a maximum of twelve and a half per cent (12.5%) of the actual cross-sectional area of the sewer.

The reduction in cross sectional area of existing sewer lines after rehabilitation shall be exclusively in terms of physical dimensions. The Contractor shall support the quoted percentage reduction in cross sectional area by submitting detailed calculations. The improvement in hydraulic capacity shall not be taken into account for calculating cross sectional area reduction.

The physical dimensions of the sewer will be measured after desilting works and the actual diameter and cross-sectional area will be agreed prior to submission of detailed liner design by The Contractor. For Tender purposes, the Nominal diameter of sewer shall be used.

The reduction in hydraulic capacity of the sewer system as a result of rehabilitation has significant implications on the long term serviceability of the sewer system. If the reduction in the physical cross sectional area of the renovated sewers can be kept to a minimum then this will enhance the long term serviceability of the sewer network.

Any lining system resulting in the reduction of the physical cross sectional area exceeding the above limit may be considered as non-conforming in terms of this specification and may be rejected without reason.

7.36.19.2 Design Responsibility

The Contractor shall be responsible for the suitability and correctness of design calculations necessary to substantiate that the lining system will be suitable in the long term for loads and all conditions experienced by the lining.

The Contractor shall submit final design calculations based on the actual site parameters for each length and size of sewer to The Engineer for approval prior to commencement of liner fabrication.

The design requirements set down in this clause shall be considered as minimum requirements. The Contractor may adopt more conservative assumptions or design methods should they consider it necessary to accept full design responsibility.

Review of the Contractor's design calculations shall not be construed as acceptance of the calculations. Responsibility of the design shall remain with the Contractor.

7.36.19.3 Design Life

The service life of the installed lining system shall be not less than fifty (50) years under live sewer conditions. The Contractor shall produce documentary evidence to substantiate that the system he offered shall have minimum fifty years of service life

7.36.20 Structural Design of Liners

7.36.20.1 CIPP Liner

The lining system offered shall be better than or equivalent to the lining systems suitable for Type 2 structural liners addressed in WRc, SRM manual, (2001) 4th Edition and ASTM F1216-03.

The structural design technique shall follow the design guidelines given in Sewerage Rehabilitation Manual, (WRc, SRM Manual (2001), 4th edition) or ASTM F 1216-03 (for CIPP) or other structural design methods of International Standard.

All designs shall be checked for critical buckling pressure based for both hydraulic loading and soil and traffic loading.

The Contractor's attention is drawn to the phenomenon that most of the polymeric liner materials do creep with time, resulting in substantial change in their engineering properties. The Contractor shall use only the proven long term engineering properties of materials in the structural design of the liner. However, for any short term temporary loadings, such as from handling and transporting the liner, grouting pressure etc. the Contractor may use the short term engineering properties in the design.

The Contractor shall state the short term and long term engineering properties including the stiffness values assumed for the materials in the design and submit documentary evidence to support the values of short term and long term stiffness assumed.

The Contractor shall make provision in his prices to conduct tests on site to prove that the materials actually used on site have achieved the short term values assumed in the design.

7.36.20.2 CIPP Lining Systems

This specification is applicable for the following lining systems and material types:

- ❒ Structural Lining with cured in place pipes (CIPP) formed using resin impregnated tubes for all sizes of pipes.

Use of the systems mentioned above does not necessarily imply that they will satisfy the requirements of this specification. Structural linings may for instance require strengthening by inclusion of special reinforcing layers and corrosion protection layers to satisfy design requirements of the specification.

7.36.20.3 Reference Documents and Standards

AS/ANZ 2566.1	Buried Flexible Pipes - Part 1: Structural Design
ASTM D-638	Test for Tensile Properties of Plastics.
ASTM D-790	Test Methods for Flexural Properties of Reinforced Plastics and Electrical Insulating Material.

ASTM D-2412	Test for Apparent Tensile Strength of Reinforced Thermosetting Plastic Pipe and Tube.
ASTM D-2587	Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impresser.
ASTM F-1216-03	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin Impregnated Tube.
ASTM F-1743	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured–in-Place Thermosetting Resin Pipe (CIPP)
ASTM D-5813	Standard specification for Cured–in-Place Thermosetting Resin Sewer Piping Systems.
ASTM D-2990	Standard Test Methods for Tensile, Compressive ,and Flexural Creep and Creep-Rupture of Plastics
ASTM F-2090	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Glass Reinforced Plastic(GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP) (steam or UV cure)
BS 1881	Testing Concrete Part 102 Method of Determination of Slump Part 116 Method for the Determination of Compressive Strength of Concrete Cubes.
BS 2782	Methods of Testing Plastics Method 335a Determination of Flexural Properties of Rigid Plastics - Method 1003 Determination of Tensile Properties.
ISO11296-1 & 11296-4	Specification for Renovation of Gravity Sewers by Lining with Cured-In- Place Pipes.
WIS 4-34-02	Specification for Glass Fibre Reinforced Plastic (GRP) Sewer Linings.
WRC, SRM	Water Research Centre, Sewerage Rehabilitation Manual.
EN1120	Plastic Pipe Systems – Determination of Resistance to Chemical Attack from the Inside of a Deflected Section.
EN13566-4	Plastic Pipe Systems for Renovation of Underground Non Pressure Drainage and Sewerage Networks. - Part 1 General.
EN13566-4	Plastic Pipe Systems for Renovation of Underground Non Pressure Drainage and Sewerage Networks. - Part 4 :Lining with Cured in Place Pipes
AUST ROADS	Bridge Design Code.

IRC-AA CLASS	Indian Road Congress, Design Load Standard
ASTMI 1697	Wound Lining
ASTM D 256-1997	Standard Test Methods for Determining the Lzod Pendulum Impact Resistance of Plastics".
ASTMD 2240 - 1997	For Rubber Property – Durometer Hardness".
WIS 4-31-05	Specification For Solid Wall Concentric External Rib-Reinforced Pvc Sewer Pipe.
In case of conflicting requirements between this specification and the ASTM standards, this specification will govern	

7.36.20.4 Notation

The following notation shall apply to this specification:

Symbol	Definition	Units of Measurement
C	Ovality correction factor (Refer Clause 2.2.3.2)	-
C_b	Crown bending moment coefficient	-
D	Diameter at neutral axis of lining.	M
d_{av}	Mean internal diameter of the existing pipe	M
d_{min}	Minimum internal diameter of the existing pipe	M
D_e	External diameter of barrel of existing pipe.	M
D_f	Deflection factor	-
E_b	Ring bending modulus of elasticity of lining material	MPa
E_{bL}	Long term ring bending modulus of elasticity of lining material	MPa
E'	Effective soil modulus	MPa
FS	Factor of Safety	-
H	Depth of cover; vertical distance between the top of the pipe and the existing surface level	M
h	Overall height of lining	Mm
I	Moment of Inertia of lining wall for ring bending	m^4/m
K_b	Ratio of horizontal to vertical earth pressure	-
K	Buckling resistance enhancement factor	-

Symbol	Definition	Units of Measurement
q_{all}	Critical buckling pressure for lining	KN/m^2
S_D	Ring bending stiffness of lining (per metre length)	N/m/m
S_{DL}	Long term ring bending stiffness of lining (per metre length)	N/m/m
t	Lining material thickness	Mm
t_1	Minimum grouted annulus thickness	Mm
t_2	Wall thickness of existing sewer	Mm
w	Unit weight of soil	KN/m^3
W_g	External dead loading	KN/m
W_q	External live loading	KN/m
Δ_y	Predicted long term vertical deflection of lining	M
Δ_y/D	Limiting long term vertical deflection of lining	%
$\square_b$	Long term strain	-
v	Poisson's ratio	-

7.36.20.5 Materials

The minimum required service life of the installed lining material is fifty [50] years.

The lining system shall be comprised materials that are chemically and biologically resistant to internal exposure to sewage, sewage related gases and mild concentrations of industrial effluent for the service life of the lining. In particular the system shall be chemically resistant to prolonged high concentrations of sulphuric acid (up to 10% concentration) resulting from the bacterial conversion of hydrogen sulphide. Linings shall not be susceptible to strain corrosion under deflection (Refer test method in EN1120).

The lining material shall have satisfactory abrasion resistance to the migration of silt, sand and debris along the sewer. It shall be sufficiently robust not to be damaged by sewer cleaning equipment that may be required to remove silt or any future blockage following installation of the lining.

CIPP linings shall satisfy the minimum material requirements given in ASTM F-1216 -03 & ISO11296- 1 & 11296-4

Test data shall be provided prior to manufacture of any linings to confirm minimum material properties.

7.36.20.6 Materials for CIPP Lining

i) The Tube

The sewn Tube shall consist of one or more layers of absorbent non-woven felt fabric and meet the requirements of ASTM F1216, Section 11.1 or ASTM F1743, Section 11.2.1 The tube shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe, and stretch to fit irregular pipe sections.

The wet out Tube shall have a relatively uniform thickness that when compressed at installation pressures will equal or exceed the calculated minimum design thicknesses.

The Tube shall be manufactured to a size that when installed will tightly fit the internal circumference and length of the original pipe. Allowance should be made for circumferential stretching during inversion. Overlapped layers of felt in longitudinal seams that cause lumps in the final product shall not be utilized.

The outside layer of the Tube shall be coated with an impermeable, flexible membrane that will contain the resin and all the resin impregnation (wet out) procedure to be monitored.

The Tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated electrometric layers. No material shall be included in the Tube that may cause de-lamination in the cured CIPP. No dry or unsaturated layers shall be evident.

The wall colour of the interior pipe surface of CIPP after installation shall be a relatively light reflective colour so that a clear detailed examination with closed circuit television inspection equipment may be made.

Seams in the Tube shall be stronger than the non-seamed felt material.

The Contractor must have performed long-term testing for flexural creep of the CIPP pipe material installed by his Company. Such testing results are to be used to determine the long-term, time dependent flexural modulus to be utilized in the product design. This is a performance test of the materials (Tube and Resin) and general workmanship of the installation and curing.

A percentage of the instantaneous flexural modulus value (as measured by ASTM D790 testing) will be used in design calculations for external buckling. Retention values exceeding 50% of the short-term test results shall not be applied unless substantiated by qualified third party test data to the Engineer's satisfaction. The materials utilized for the project shall be of a quality equal to or better than the materials used in the long-term test with respect to the initial flexural modulus used in the CIPP design.

The layers of the cured CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe or point of a knife blade so that the layers separate cleanly or the probe or knife blade moves freely between the layers. If the layers separate during field sample testing, new samples will be required to be obtained from the installed pipe. Any reoccurrence may cause rejection of the work.

ii) Resin

The resin system shall be a corrosion resistant unsaturated polyester meeting the requirements of BS3532: 1990, or epoxy resin conforming to the requirements of ASTMD1763-88, including all required catalysts, initiators or hardeners that when cured within the tube create a composite that satisfies the requirements of ASTM F1216 and ASTM F1743, the physical properties herein, and those which are to be utilized in the design of the CIPP for this project.

The resin shall produce a CIPP that will comply with the structural and chemical resistance requirements of this specification and shall be capable of producing the necessary design strengths and modulus assumed in the designing of the liner where high flexural modulus used in the design or required to meet the thickness requirements to keep the cross sectional area reduction of the sewer to be minimum.

All resins used for rehabilitation in the bid must have a proven track record for CIPP lining in proposed

sewer rehabilitation work for at least 10 years. Manufacturer details of resins to be used and history of use in sewer.

The Contractor's attention is drawn to the phenomenon that most of the polymeric liner materials do creep with time, resulting in substantial change in their engineering properties. The Contractor shall use only the proven long term engineering properties of materials in the structural design of the liner. However, for any short term temporary loadings, such as from handling and transporting the liner, grouting pressure etc. the Contractor may use the short term engineering properties in the design.

The Contractor shall state the short term and long term engineering properties including the stiffness values assumed for the materials in the design and submit documentary evidence to support the values of short term and long term stiffness assumed.

The Contractor shall make provision in his prices to conduct tests on site to prove that the materials actually used on site have achieved the short term values assumed in the design.

The stiffness consistency of the as-installed liners shall be checked on site to ensure uniformity along the length of the rehabilitated sewer. Contractor shall make provision in his prices to determine the actual thickness of the as-installed liner and the engineering properties of the liner materials (especially the soft liners with considerable thickness). The procedure for cutting and testing the liners shall be proposed by the Contractor for Engineer's approval.

The Contractor shall clearly understand the difficulties of some of the liners (both soft and flexible liners) achieving a good fit to the invert of smaller size circular sewers due to difficulties in bending the liners, especially the thicker liners. The Contractor shall study the situation and design the liner thickness to ensure that proposed liner shall achieve the required bending radius.

Strain related corrosion in polymeric materials in aqueous environment has been a source of structural capacity degradation. The Contractor shall address the issue of strain related corrosion for the materials he proposes to use and shall submit his recommended design practice and the standard for Engineer's perusal and acceptance. The Contractor shall consider restricting the strain to minimum recommended values in the design codes or British Standards or in any standards/codes as accepted by the Engineer for materials known to be more prone to strain related corrosion in aqueous environment. A more stringent strain limitation would be about 0.5%

The contractor shall ensure that deflections are within the acceptable limits and show in his design that deflection issues have been adequately taken into consideration in determination of the liner thicknesses.

7.36.20.7 Material Properties for Design

Where material properties under load vary with time, material properties of the lining at the end of the fifty (50) year service life shall be used in design calculations. The exception to this is design of the lining for loads applied only during installation, which may be based on short term material properties.

The material properties used in the design shall be consistent with the composition of the lining material. Values for material properties may be nominated by the Contractor but must be capable of being substantiated by test data based on representative samples of the installed lining material. The Contractor shall make provision in the Contract for such tests to be conducted during installation.

7.36.20.8 Design Loads

Design loads shall comprise the maximum load produced from the combination of earth pressures, hydrostatic loads and traffic surcharge loads for each particular lining. Vertical earth pressures shall comprise the nominated effective overburden height of soil above the pipe without reductions for trench effects.

Maximum hydrostatic pressures from groundwater shall be determined assuming the water table is located at surface level.

Traffic surcharge loads shall be calculated in accordance with Indian Road Congress AA Class Loading standard Loads shall vary depending on the road usage as follows:

TYPE A: Main Road Multiple adjacent lanes

TYPE B: Light Road Single lane
TYPE C: Field Load

Traffic live and soils loads given in WRc SRM (2001) 4th Edition is also acceptable.

7.36.20.9 Installation Design Checks

Linings shall be checked to ensure they are stable and will not be overstressed for any intermediate states during the installation and/or curing of the particular system. These checks may be based on short term properties of the lining material.

7.36.20.10 Design Calculations

Calculations shall be provided to substantiate that linings have been proportioned to suit the design requirements of this specification. Unless noted otherwise, all calculations shall assume a minimum factor of safety of 2.For Buckling Check use factor of Safety 2.5.

The Contractor shall supply full details of their design calculations, including proof checking and review of the calculations, by a qualified professional who is familiar with design procedure adopted in the WRc manual and ASTM F-1216-03.

If requested, the Contractor shall also provide a copy of the calculations for short term design checks.

7.36.20.11 Definitions for Pipe Condition

For the purpose of this specification and for design purposes, the condition of the existing sewer body has been classified as the following:

Fully Deteriorated:

The sewer body has lost a sufficient degree of its original structural capacity that it cannot be relied upon to support applied loads for the next 50 years. The lining is expected to act as a structural replacement for the original sewer to bear the full load from the ground, traffic and ground water.

7.36.20.12 Design for Circular Pipes

i) Design of Liners

All liners must be capable of resisting a combination of maximum load arising from soil, water and traffic loading imposed on the lining.

All liners shall be designed in accordance with WRc /ASTM design procedures.

All liners shall also satisfy the requirements of this Specification for Type II standalone liners.

ii) TYPE II Linings – Hydraulic

The design shall be based on the buckling strength of the lining with account taken of the enhancement provided against a buckling mode of failure by the existing pipe.

Design thickness shall be sufficient to withstand the hydrostatic pressure due to groundwater without collapsing.

The following equation shall be used to determine the required stiffness of the lining:

$$q_{all} = \frac{24 \times K \times S_{DL} \times 10^{-3}}{\left(1 - \nu^2\right)} \times \frac{C}{FS}$$

where

FS = *2.0*

K = *7.0* *when lining and pipe are in intimate contact or the annular gap is grouted.*

= *4.0* *when the gap between the lining and inside of the pipe exceeds a mean value of 1 mm.*

$$C = \left(\frac{\left(1 - \frac{d_{av} - d_{min}}{d_{av}}\right)}{\left(1 + \frac{d_{av} - d_{min}}{d_{av}}\right)^2} \right)^3$$

$$S_{DL} = \left(\frac{E_{bL} \times I}{D^3}\right) \times 10^6$$

The ovality shall be calculated as per ASTM F1216-03.

Minimum value for ovality of the existing sewer will be 2%.

iii) Type II Lining Standalone

The lining shall ignore any contribution from the original conduit and be designed to support all imposed loads in its own right.

The lining shall be designed to satisfy the critical performance criteria of vertical deflection, strength, and buckling under maximum combined loads. Contractor must validate Soil Modulus from existing soil data available along sewer routes when submitting final design.

The lining must also satisfy the design for hydrostatic loads.

(1) DEFLECTION

1. The predicted long term vertical deflection shall be less than six percent (6 %) of the diameter of the lining when calculated in accordance with the following equation,

$$\frac{\Delta_Y}{D} \times 100 = \frac{0.1 \times 10^{-3} \times \left(\frac{(W_g + W_q)}{D}\right)}{8 \times 10^{-6} \times S_{DL} + 0.061\ E'} \times 100 \leq 6\ \%$$

Where

W_g = $w\ H\ D$

w = $18\ kN/m^3$

E' ≤ *6.0Mpa (is the maximum allowable Soil Modulus if no voids are present around the sewer and the body of the sewer is stable)*

(2) FLEXURAL STRAIN

The long term flexural strain developed in the wall of the lining for any load or load combination shall not exceed the permissible value appropriate for the lining material. The predicted long term strain shall be calculated as follows:

$$\varepsilon_b = D_f x\ (\Delta_y/D) x (t/D)$$

$$D_f = \frac{3.33 \times 10^{-6} \frac{S_{DL}}{E'} + 0.00136}{1.11 \times 10^{-6} \frac{S_{DL}}{E'} + 0.000151}$$

(3) BUCKLING RESISTANCE

The lining shall be designed so that its buckling resistance is sufficient to support the imposed loads when calculated in accordance with the following equation:

$$q_{all} > w\left(\frac{D_e}{2} + H\right) + \frac{W_q}{D}$$

where

$$q_{all} = \frac{\left(S_{DL} \times 10^{-6}\right)^{\frac{1}{3}} \left(E'\right)^{\frac{2}{3}} \times 10^{3}}{FS}$$

The Factor of Safety (FS) shall be 2.5.

If requested calculations shall also be provided to demonstrate that the existing structure will not be overstressed by any combination of applied loading or reactions from the installation or performance of the lining

7.36.20.13 Retention of Existing Integrity of Sewer

Rehabilitation Activities Affecting the Integrity of the Sewer.

No activity of the Contractor during preparation of the conduit and installation of the lining shall adversely affect existing structural integrity of the sewer No reaming or grinding of inner surface of the sewer body may be permitted for CIPP linings in man-entry pipes.

No reaming shall be permitted to be carried out on RCC Pipe sewers.

7.36.20.14 Method Involving Internal Loading

The structural capacity of the existing sewer is unknown. Any method involving internal loading on to the sewer body during the construction operation will be viewed cautiously.

7.36.20.15 Working shafts (Starting and Ending Pits)

The Contractor shall note that no open excavation will be permitted under normal circumstances along the road or the sewer line and he shall thus select the renovation system that requires minimum or no excavation. However, widening of existing manhole chamber up to a limit of 1.5m may be allowed subject to the Contractor obtaining necessary traffic permission from the authorities. It may be necessary to provide decking, especially in busy streets, and in which case the Contractor shall make provision in his rates for providing decking as required. The decking details shall be submitted to Engineer for approval.

Generally, the Contractor shall be allowed to work in night in streets where the traffic is heavy. However, the works can be continued during busy hours during the day provided the Contractor

shall obtain necessary permission to work in such hours from the traffic authorities and such permission shall be submitted to the Engineer for him to authorise such work. Contractor is deemed to have included in his rates the cost of construction of all starting and ending pits

7.36.20.16 General

The manufacture of the lining shall be carried out in accordance with a specification purpose written for the particular system. This specification shall detail all labour, materials and equipment required to combine the various constituents to produce the lining ready for delivery to site. The specification shall include reference to appropriate standards for the manufacture.

The purpose written specification shall include testing and inspection work to be carried to verify the dimensions and quality of the manufactured lining.

A project specific Quality Control System, shall be also developed during the execution of works for site verification, manufacturing and installation of the liner.

7.36.20.17 Additional Requirement for Manufacture of CIPP Linings

The lining tube should be manufactured in an ISO certified facility.

The specification shall include reference to appropriate standards for the manufacture such as the following:

ASTM F1216 -03 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin Impregnated Tube. EN 13566.4 Plastic Pipe systems for renovation of underground non-pressure drainage and sewerage networks. Part 4: Lining with cured in place pipes WIS 4-34-04 Specification for renovation of Gravity Sewers by Lining with Cured-In-Place Pipes

The perimeter of the CIPP lining tube shall be dimensioned such that when installed it forms a close fit with the inside wall of the sewer. The manufactured length and thickness of the CIPP lining tube shall include allowances for any longitudinal or circumferential stretch during installation.

The lining tube after impregnation shall be provided in lengths such that no jointing is required between points of access to the sewer.

7.36.20.18 Appearance and Surface Condition

The Cured-In-Place Pipe lining system shall be a composite tube, consisting of one or more layers of polyester felt or similar approved. It shall have an integral impermeable membrane, impregnated with unsaturated synthetic resin (Polyester, Epoxy or Vinyl ester) or similar approved which, after inversion or winching into the pipe, will be in continuously firm contact with the host pipe wall, with the coating on the inside.

The lining shall comply with the relevant provisions of ASTM, WRc & WIS 4-34-04 or equivalent accreditation.

The lining shall be fabricated in such a length that when installed, it will occupy exactly the length of the pipeline between the launch and reception manhole chambers and, in addition, the flow through channels of the launch, intermediate and reception manhole chambers. The lining shall be of the correct diameter so that on inversion or winching in-situ it does not wrinkle by more than 1% for linings in sewers equal to or greater than 600mm bore.

The dimensions of the lining shall take account of longitudinal and circumferential expansion and any variation in existing pipe internal diameter (i.e. existing sewer bore), including loss of pipe wall thickness due to hydrogen sulphide corrosion and deformation of pipe.

Where several layers of felt are required, the inner layer shall be stitched or spot welded to form a tube. Each successive layer shall be individually wrapped around the previous one and spot welded or stitched together. The outer layer of felt shall have an installation tube pre-bonded to it, or a sheet of this material shall be wrapped around the completed felt tube, lapped over and bonded to the felt to form an airtight seal. Where pre-bonded material is used a covering strip shall be bonded over the seam to form an airtight joint.

7.36.20.19 Pre - Liner

Pre-liner to be used only in case of pull in pipe. A pre - liner composed of a polymeric membrane or similar approved material which may be integral with the lining shall be used to prevent the resin from being washed out of the Cured-In-Place liner by infiltration as well as contain all odour, and assist in the curing process (temp insulation from omniscientwater/sewage).

The pre-liner shall be non-porous, completely free from pin holes and bubbles, air tight and impervious to resins even when inflated to 20% over its normal size.

7.36.20.20 Trial section

The contractor and the testing standards shall carry out a successful demonstration trial and procedure shall be agreed with the Engineer before commencing the trial. One sewer line as selected by the Engineer shall be lined as a trial section and Quality Control tests performed as detailed herein for approval of the methodology proposed by the Contractor.

The Contractor shall allow for any further requirement of the Engineer to modify his Method or material subsequent to the trial, to complete the work satisfactorily. The Contractor shall include in his rates for complying with all the foregoing requirements of this Clause.

7.36.20.21 Standard of Finish

(a) The lining shall be close fit with annular space grouted against the original pipe along the whole of its length and lateral connections shall be clean with no projections;

(b) The lining shall be free from visible defects including foreign inclusions, dry spots, air bubbles, pinholes and pimples.

In the event that the lining is unacceptable due to partial collapse or due to an unacceptable any degree of defects such as protruding fibers, air voids, crazes cracks, blisters or foreign matter that might impair the performance in service. The internal surface of the lining shall be smooth. The Contractor shall remove and replace with a lining of the same thickness as the failed lining at his own cost. The Contractor shall submit to the Engineer for approval a complete method statement of these or any other remedial processes he proposes to use. All such remedial works of renovation, repair or replacement shall be carried out at no cost to Employer.

7.36.20.22 Reinstatement of Connections

All laterals shall be cut open and reinstated in consultation with the Engineer-In-Charge/ Consultant.

7.36.20.23 Finish (Hydraulic Acceptability)

The installed lining shall be continuous over its length and shall be free of any defect which is likely to affect the satisfactory hydraulic performance of the lined conduit or cause accumulation of solids.

7.36.20.24 Quality Control

Type of tests and quality control tests shall be carried out as per Quality Control/Assurance Procedure to be submitted by the Contractor and approved by the Engineer.

The Engineer shall inspect testing equipment, witness tests and review documentation as he so wishes.

7.36.20.25 Process Control Sheet

The Contractor shall complete a Process Control Sheet for each sewer undergoing rehabilitation and submit a copy to the Engineer once rehabilitation has been completed.

The Process Control Sheet shall include the following information unless otherwise modified by the Engineer:

Location details, including upstream, downstream and all internal dimensions of the sewer, manhole chamber reference numbers, and street location;

Material(s) used in the liner,

Condition (cleanliness, infiltration etc.) of sewer and manhole chambers (intermediate, immediately upstream and downstream) prior to re lining;

Time of despatch of liner and arrival at site

Weather conditions immediately prior to lining and during the lining
process; Time of commencement and completion of re-lining works;

Material properties and Resin (as may be required) details:

Quantity, weight of components, batch number of resin / hardener used Temperature and Time

The Engineer so instruct, the process control sheet and other relevant database should be supplied by the Contractor in electronic format.

The Contractor shall allow in his rates for complying with the above quality control requirements.

7.37 PARTICULAR TECHNICAL REQUIREMENTS – WATER METERS

7.37.1 AMR Domestic Water Meters

The scope incudes Supply, Installation and maintenance of AMR water meters of various sizes including Software, Hand Held Unit for Reading AMR Meters, and Water Meter Box with Operation and Maintenance for five years in the service area.

General Requirements for AMR Water Meter System are as follows, however, these requirements should in no way affect the battery life throughout O&M Period.

1. The water meters shall have the anti – magnetic properties / immunity, as specified in ISO: 4064 – 2014, when tested with385 mTesla to 400 m Tesla magnet is mandatory. For AMR system resistivity against application of magnet is not required.

2. The water meters (ISI or EEC marked) shall be supplied complete with brass nuts and nipples as per specifications conforming to IS-779: 1994 or Class -B, ISO-4064: 2014 standard with ISI/EEC/OIML/MID certification mark shall be with protection class of IP68. All meters along with AMR module shall be of protection class of IP68.
3. The remote reading of AMR water meter needs two way communications. The remote readings of AMR water meter should be obtainable by either 'Walk by' or 'Drive by' methods.
4. The AMR trans-receivers shall be wireless and have IP 68 protection class i.e. no ingress of water after submerging AMR water meter for 48 hours under 3 meters of water column. AMR shall be obtainable even under submerged conditions & lid of the chamber closed.
5. The AMR trans-receivers shall be used (RF End units/ Wireless RF transmitter/Receiver) for communication and remote reading. It shall be either inbuilt or directly fitted on the water meter without wires. If the water meter & AMR trans-receivers are independent units then they must be from the same manufacturer.
6. Remote readings of different water meters shall be obtained with single command. The remote readings shall have instant reading facility. The remote readings and dial readings of water meters shall match at all the times.
7. All AMR readings shall show the date and time of the reading recorded.
8. The AMR system shall have facility to detect the reverse flow in water meters readings on the Hand Held Device (HHU) i.e. AMR reading device and on computer screen.
9. The AMR system shall have the facility to record the abnormalities like application of very high consumptions, water leakages etc. along with necessary alarms in HHU and in software
10. The battery life of AMR water meter shall not be less than 10 (ten) years from successful installation & commissioning of said AMR water meter along with its AMR system, the battery life shall be calculated by considering the monthly remote reading. During remote reading the battery life and alert for replacement of battery if warranted of AMR water meter shall be displayed / indicated on HHU.
11. If the AMR communication frequency is using / operating on paid frequency band, then the AMR water meter manufacturer has to produce the valid copy of license issued by Govt. of India / Deptt. of Telecom (DOT), for using the said operating frequency band.
12. The manufacturer shall specify the frequency of the AMR operating system & shall possess the necessary license of said operating frequency, as per norms of Department of telecommunication, Govt. Of India issued by Government of India (GOI) / Department of Telecom (DOT). The cost of the same will be presumed as included in the quoted rates. In case, if bidder claims frequency of the operation in the free band, necessary documents / clearance from GOI / DOT shall be submitted to the Employer. However, the Employer reserves the right for acceptance of offered frequency & Power subjected to the guidelines issued by DOT / WPC.
13. The AMR water meter shall not get affected for its AMR functioning due to High Tension or High Voltage line concentration.
14. All the time electronic index of the water meter shall match with mechanical index.

15. The pressure loss in the meter shall not be more than 0.63 bar as per ISO 4060-2014.
16. The register must be based on absolute encoder / counter. The system must read the register in 8 points per pulse to have clear reading of the first dial.
17. Wireless RF transmitter/Receiver must be sealed, have an antenna, battery and must be integral part of the water meter register forming IP 68 protection.
18. All AMR water meter systems to be provide pipework, fittings, valves, fittings, specials another associates auxiliaries as per IS-779: 1994 & ISO 4064 standards
19. All AMR water meters and accessories shall be manufactured from materials of adequate strength and durability. The materials which come in contact with water shall not create a toxic hazard, shall not support microbiological growth and shall not give rise to unpleasant taste or De-chlorination to water.
20. All AMR water meters shall be supplied with a tubular strainer in the inlet of meter, the total area of holes not less than twice the area of nominal bore of the pipe.
21. The meters shall have Smart alarms for Leak, Burst, Dry, Reverse, Tamper etc.
22. The meters shall be supplied complete with brass nuts and brass nipples. Strainer & sealing shall be provided as per relevant IS provision.

7.37.2 Applicable Standards

The contractor should follow the required and the latest standards of higher grades as given below:

IS 2373	Indian Standard for bulk water meter specifications
IS 2401	Indian Standard for Code of practice for selection, installation and maintenance of domestic water meters
IS 6784	Indian Standards for methods for performance testing of domestic type water meters
IS 779:1994	Indian Standard sixth edition for the specification of domestic type water meters
ISO: 4064 –2014	International standard for AMR system for water meters.

7.37.3 Technical Specifications:

1	Meter Type	Multijet, magnetically coupled, inferential type AMR water meter
2	Power Supply	Battery operated for the sensor and calculator with a battery life of minimum 10 years to ensure recording at all times.
3	Meter Life time	Minimum 10 years
4	Protection Class	Must comply to IP68 Standard for indoor and outdoor operation, including fully submerged installations
5	Approvals & certification	The meter should be type approved and verified according to international water meter Standard OIML R49 and or ISO 4064.The meter should be EEC/MID approved.
6	Accuracy	+/- 2 % or better over typical operating range and temperatures. The water meter should maintain its accuracy over its life time
7	Calibration	3-Point calibration with calibration certificate available for each unit.
8	Material	The water meter body shall be made of corrosion resistant material like brass, bronze, stainless steel or carbon steel.
9	Pressure Rating	Pressure Rating of > 10 bars
10	Environmental Temperature	0 degree C to 50 degree C
11	Lockable Cabinet	Suitable as per Meter size & site conditions.
12	Data Protection and tamper proof	The meter should be tamper proof with suitable data protection of calibration and revenue parameters.
13	Self-diagnostics for error detection	The smart meter should have advanced diagnostics with active alarm(s) indicated on display.
14	Access to information	Display with.> 8 digits for main information. Index, menu and status symbols for dedicated information.
15	Measuring Units	The measuring unit should be m3 for volume.
16	Facility for Remote Communication interface	The water meter should be configured with battery operated remote reading capability using point-to-point RF.

17	Installation	The water meter shall be approved for Class B installation in both the horizontal and vertical installation positions.

7.37.4 Material of Construction

i. The manufacturer shall provide specific details of materials used for various parts of the meter which must meet the specifications for the material of construction of the individual parts of the meters as per IS 779:1994 (latest amendments) or ISO 4064: 2014.
ii. The body of the meter shall be of either Brass or Bronze. Material that come in contact with the water supply shall withstand 2 ppm (parts per million) of chlorine residual in the water supply and shall be resistant to corrosion.
iii. The water meter and accessories shall be manufactured from materials of adequate strength and durability. The materials, which come in contact with the potable water, shall not create a toxic hazard, shall not support microbial growth, and shall not give rise to unpleasant taste or discoloration in the water supply.
iv. The spindle and bearings inside the hydraulic chamber shall be made of polished stainless steel with hard metal tip/ sapphire.
v. An anti-fraud shield of stainless steel is mandatory to avoid magnetic tampering on meter or to protect the magnetic transmission.
vi. The internal pressure cup shall be made of Engineering plastic. The lower case of the meter shall be painted with thermal painting externally. The painting materials should be safe for human uses and not affect human health. Painting colour will be decided after award.
vii. Meter will be provided with monolithic seal with copper/SS wire or Rust proof sealing wire
viii. Variation in weight of the meter will be permissible to +5% of the weight approved for the sample meters after testing at FCRI Kerala.
ix. Each meter shall be supplied in individual box with its accessories and test certificates and guarantee card. The no. of individual boxes of meters shall not exceed 30 nos in each carton

7.37.5 Requirement for Totalizer and Totalizer Shield

The Totalizer shield/ Register shall be designed in such a way that if the Totalizer shield/ Register protective glass is broken for a reason or another the Totalizer shield/ Register cannot be removed from its place. Totalizer shield/ Register protective cover shall be made of sturdy glass and shall have a thickness of not less than 5mm and shall pass specified tests.

Totalizer :-

i. It shall be of straight reading type.
ii. The totalizer shall register in cubic meter units
iii. The initial totalizer reading should be less than 1KL
iv. The totalizer shall consist of a row of at least 4 in-line consecutive digits to denote minimum reading of 9999 KL. Another two digits shall register flows in submultiples of Kilo litres and should be of a different colour.
v. The least count / resolution of water meter should be at least 1liter.
vi. The totalizer should be of closed type.
vii. The totalizer must be suitable for test on an electronic test bench.
viii. Totalizer shall be metallic (either copper CAN having 5mm thickness or any other suitable material) fitted with glass to maintain IP 68 protection class

ix. Meter shall be provided with monolithic seal with copper wire.

7.37.6 Meter Reading

i. The meters shall be read automatically from the central control centre with the help of fixed network.

ii. The meter should be provided with remote Data collector / Concentrator with aerial / panel antenna for outdoor installation, 2G/3G/4G modems necessary Cabinet & Extra antenna wire for Outdoor installation, 4) Android app / Cloud base Meter Reading Software

iii. The data concentrator/ collector should be capable of reading a minimum of 1000 households each and suitable number of signal repeaters shall be provided for areas with weak network without any additional cost to the employer.

iv. The device shall show exact physical location of water meter on GPS Map as per location (coordinates) entered into the system after meter installation.

v. The Meter Reading software should display clearly active alarms for each meter.

vi. The Meter Reading software should have capability to store full customer and meter information for each meter.

vii. The Meter Reading software should be able to display the statistics of the reading route, including but not limited to read meters, unread meters,

viii. The data transfer from the meter to the-reading software shall be via GSM/ GPRS.

ix. The software shall alert the meter reader for unread accounts in a specific area.

7.37.7 AMR System:

i. The remote readings of AMR water meter should be obtainable by Fixed network' method.

ii. The AMR trans-receivers shall be wireless and have IP 68 protection category i.e. no ingress of water after submerging AMR water meter

iii. All AMR readings shall show the date and time of the reading recorded.

iv. The AMR device of the water meter shall be tamper proof.

v. The water meters fitted with AMR shall have the facility to transmit reading in submerged condition & the remote readings should be obtained with water meter in submerged condition

vi. The AMR system should retrieve required data from every meter without reduction in battery lifetime and/or reading speed.

vii. The AMR meters and all its related ancillary equipment shall be provided by the same manufacturer so that compatibility issues are not encountered.

7.37.8 AMR Software:

a. The software shall give output, at least in the CSV (Comma Separated Value)/txt/xls.

b. The Route Management software must be capable of running on a standard PC compatible with minimum Pentium processor. In addition the software must run under Windows95, Windows XP Professional, Windows Vista, Windows 7, Windows 8 and / or latest version of windows operating system.

c. The software shall allow the PC operator to review and edit any account in Route Manager database. Also, the PC operator shall be able to generate route and activity reports. .

d. The software shall alert the meter reader for unread accounts in that route.

e. The software shall enable the user to specify the data to be exported from the database for transferring to billing system.

f. The software shall take routes from an existing database for loading into a reading device.

g. The software shall select the routes to be read, and assignment of routes to a reading device and dynamic updating of routes and sub-routes to be enabled.

h. The software shall upload routes from the reading device.

i. The software shall post the reading from the reading device onto appropriate accounts within the database.

j. Software shall be able to set meter status such as, meter not okay, reading not reliable, meter maintenance required etc

k. The GPS coordinates shall be visualized in the PC software itself.

l. Data should be available in hand Held Unit for minimum 90 days in the route as well as the data along with historical data in the output in the XML/CSV format.

m. Different type of indications such as read meter/unread meter, meter to be read, meter read with observation, meter with alarm, unreadable meter, meter not okay, reading not reliable, meter requiring maintenance should appear on HHU.

n. The bidder shall be responsible for taking reading of AMR Meters at a frequency defined in the schedule of supply and shall be responsible for uploading the data in MCL billing unit and its integration with existing MCL's RMS system for generation/printing of consumer bill during the contract.

o. Software should have option of upgrading the system so as to enable sending alerts to the consumers through SMS regarding water meter reading, billing, payment, complaints and redressal etc.

7.37.9 Warranty

All the supplied smart water meters, their peripherals and equipment, etc., must have a written warranty from the manufacturer covering not less than 10 years from the date of commissioning.

7.37.10 Maintenance liability

All the installed smart water meters, their peripherals and equipment etc. will be subject to a defect liability period of 10 year beginning from the successful commissioning date. This means that if there is a malfunction or breakdown within the period the contractor will be responsible for making good the same by repair/ replacement at his cost.

The accuracy of the installed water meters will be tested if desired or if disputed and if the test results not found accurate within the acceptable / permissible limit, the contractor will replace the meter free of cost.

When there is a malfunction the contractor is expected that the problem will be resolved within 48 hours of receiving the information. In case a spare part has to be imported then the repair should similarly take not more than 21 days.

The contractor should do a classification of what malfunction/breakdown to be given 48 hours or 21 days. This should be submitted as part of SIP. The list must be exhaustive and include all elements and how they can be detected.

7.37.11 Spare parts

The Contractor/supplier must show proof that spares for all the supplied/installed items are available and that they will continue to be produced for the next 10 years at the least. It will be preferable for the spares to be within the country, and full explanation given of their availability.

7.37.12 Marking on the Meter Body:

All water meters shall have following markings on dial/ cap.

i. Class "B"
ii. Multijet/ Model Name
iii. As per ISO: 4064-2014.
iv. EEC/ISI/OIML/MID Mark and approval no.
v. Make/Brand
vi. Sl.No. / Year of Manufacture.
vii. Size
viii. Embossing /engraved on meter body
ix. Direction of flow of water on both sides of the body of meter

7.37.13 Specific Requirements

As a part of the inspection and testing requirements of the products, 1% of the meter supplied in each lot shall be sent for accuracy testing to an independent testing laboratory acceptable to the Employer such as FCRI Kerala. Based upon the outcome of the test results the lot will be accepted, otherwise the Employer shall have the prerogative of rejecting the total lot and the contractor has to provide replacement of the total lot. The cost of the testing of the 1% sample meters need to be borne by the contractor.

7.37.14 Lab Testing

The lab testing of water meters shall include following tests as per ISO: 4064:2014 standards. The same will be conducted at FCRI, Kerala.

i. Accuracy testing of water meters at Qn.
ii. Accuracy testing of water meter at Qn after clamping the magnet on the water meter.
iii. IP 68 testing of water meter& AMR system.
iv. Remote reading of water meter in dry i.e. open air condition.
v. Remote reading of water meter in submerged condition i.e. under water, with under variable water depth conditions.
vi. Remote reading with different tamper alarms for back flows, magnet and physical damage, etc.
vii. Response time of AMR reading on HHU.
viii. Visual inspection of AMR water meter and its AMR system along with its software.
ix. Real Index test i.e. all the time electronic index of the water meter shall match with mechanical index.
x. Demonstration of uploading of readings from hand held unit to PC and vice versa.
xi. Life cycle and endurance test.

It is responsibility of the contractor to arrange the calibration of all AMR meters and bear all inspection charges and incidental charges. If the manufacturer has an ISO 17025 accredited calibration lab, then the same will be acceptable provided necessary documentation is provided. The necessary test certificates with distinctive meters shall be provided before installation of meters

7.37.15 Field Testing

After completing the installation of AMR water meters in one complete water supply DMA or 1000 nos whichever in minimum, the contractor shall demonstrate the following before taking up further installation in the service area:

i. Remote reading of individual water meter from a maximum distance of 200metres with clear line of sight under submergence condition with lid of chamber in closed position. This test is to be conducted during field demo as well as installation in main work.

ii. Remote reading of individual water meter from a maximum distance of 100metres with obstruction of any structures under submergence condition with lid of chamber in closed position, with walk by mode.

iii. Remote reading of grouped /routed water meter from a maximum distance of 150 meters with clear line of sight under submergence condition with lid of chamber in closed position, with walk by mode during field demo as well as after installation in main work

iv. Remote reading of grouped / routed water meter from a maximum distance of 100metres with obstruction of any structures under submergence condition with lid of chamber in closed position with walk by mode during field demo as well as after installation in main work.

v. On site search facility in the AMR device / HHU and software.

vi. Remote reading for special cases like back flow, magnetic tamper, physical tamper, etc. and their respective tamper alarms in HHU and software.

vii. To check the backflow tampering indication on HHU screen & software along with display of its quantity and period of backflow.

viii. Auto search facility of AMR water meter at site in HHU.

ix. Data acquisition speed of AMR reading on HHU at site for individual read and for group / route read.

7.37.16 Hand Hold Unit (HHU)

i. The hand held device or reading device shall have the sufficient memory (minimum 4000 reading data) for storage of maximum data / reading along with sufficient power back up.

ii. The HHU shall have the onsite search facility, to locate the exact physical location of water meter in particular area and to obtain the corresponding details of it. The PC should be connected via USB to HHU. The readout device and HHU should have USB port to connect with computer device for exchanging the data.

iii. The HHU should be adjustable back light, sun light readable, colour display and touch screen.

iv. The HHU shall have minimum 64 MB flash memory and 128 MB RAM.

v. The battery of HHU device shall give power back up for at least 5 hours continuously.

vi. The unit must be able to withstand three foot drop on concrete.

vii. The handheld must be ergonomically designed to be comfortable for handheld meter reading.

viii. There must be audible beep when indicating key has been pressed, there must also be an auto repeat function on keys and a rapid response between keying and seeing results on the screen.

ix. The handheld must come with an integrated intelligent fast charge capability that allows full charge within 5 hours.

x. The hand-held must have integration with Global Positioning System (GPS) for route monitoring and configuration.

xi. The read-out device should be connected to the Hand held device and needs to be USB powered.

xii. The quantity of HHU may vary at the time installation based on capacity of HHU and location/cluster size of meters. Successful bidder has to quote item rate for HHU.

xiii. Since HHU integration for route monitoring and configuration is required, bidder should adopt off field method. However field experience should also be utilized to optimize the grouping of meters. HHU should also have the facility to create route, modify route on site and to arrange in desired sequence as per site conditions.

xiv. HHU should be a single unit with required storage capacity and capable to receive required data from already defined numbers of installed meters through radio frequency and to download the same to the base computer.

xv. HHU shall have at least 3 different level of security or as directed by Engineer-in charge.

xvi. In case of AMR reading, if reading is not captured due to some reason, HHU should have capability to record data manually along with route data to be downloaded with notification of cause of manual reading. The issue should be resolved within 15 days and no manual reading will be allowed. Next billing cycle meter will be treated as unread and will be attracted action under relevant clause for that particular meter

xvii. HHU should not have option of editing the meter reading.

7.37.17 House Service connections*:*

i. All service pipes and fittings from the connection on the water main to any premises shall be laid by the Contractor as per specifications and the approved drawings The connection pipe shall be laid in the ground and shall not be less than 45 cm below the surface unless laid inside a building. All pipes shall be laid or fixed in such a manner as not to be exposed to the heat and not to cause any damage to any consumer's pipes and fitting and there should not be any risk of mixing waste water or cause contamination of water. The material of the pipes and fittings shall be got approved from the Engineer-in-charge before use. The position of the stopcock on the connection pipe shall be decided by the Contractor. All cocks and taps fitted to the service pipes in any premises shall be of a screw down pattern and of quality approved.

ii. No pipe used for the conveyance of water shall be laid or fixed which shall run through any drain or any place where water through such pipes is liable to become polluted or contaminated or where the pipe is likely to get damaged. However, in unavoidable cases such consumer's pipe may pass through an exterior air tight and water tight pipe or jacket of cost iron or other material approved by the Executive Engineer of sufficient length and strength and of such construction as would provide adequate protection to the inner pipes. The cost of which is to be borne by the Consumer.

iii. Every premises supplied with water shall have its own specific connection pipe and no connection pipe shall be used to supply water to more than one premises.

iv. The position of stop cock on the connection pipe shall be decided by the Contractor who shall have exclusive control over this stop cock and its operation.

v. For connections of sizes 25 mm and above, the stop cock will be fitted with a crutch of spindle head of specific design to suit a key or wheel kept by the Contractor.

vi. The leakages upto the stop cock or up to the meter without stopcock shall be removed by contractor at his cost.

7.37.18 Making House Service Connections

One Service connection means one tapping from a distribution main / sub- main including one tapping saddles, elbows, and service pipe from tapping point to the chamber near property boundary or inside the property as per the direction with U-ball valve.

MATERIAL

High Density Polyethylene pipe (HDPE) below ground level and MDPE pipe above Ground level shall be used for house service property connection.

7.38 PARTICULAR TECHNICAL REQUIREMENTS – SURVEY & INVESTIGATIONS

7.38.1 Consumer Survey

A complete door to door consumer survey to ground truth the footprints and the properties in the service area shall be carried out. The Contractor shall undertake a door-to-door survey of all properties whether connected to the network or un-connected and obtain the details in regard to name, address, number of resident members, categories of general residential households (independent housing, group housing connections and apartments), urban poor households, government housing, non-domestic, commercial, institutional, religious places, industrial and fire services and any other category of resident, consumers income status in the Service Area ,availability of water connection, metering status, estimated consumption levels, alternate water supply arrangements, existing sewerage system , method of disposal of wastewater, willingness to pay, etc. The contractor shall get the data from employer about the authorised water connection and their location of properties. The data collected from household survey shall be geocoded. This geospatial database will be used for the water demand of each property to be collected at the junction of distribution network pipe and the system shall be designed and modelled accordingly.

7.38.2 Internal Inspection of Sanitary Sewer Mains By CCTV Camera Including All Videos And Reports

Inspection of all existing sewers and storm drains shall be done by means of a Television Camera to determine the conditions of the pipe as regards to the following:

- Inspect sewers/storm drains to observe and record structural defects, service defects and
- to assess thoroughness of cleaning.

The contractor shall code the sewer condition in accordance with the requirements of the UK - Water Industry, Engineering and Operations Committee, (WRc) “Manual of Sewer Condition Classification” Third Edition, August 1993 and “Addendum” dated February 1996 and include the findings in an inspection report. Code all observations in accordance with WRc “Manual of Sewer Condition Classification”.

Pictures must be clear and in focus and must not be hazy due to steam or water vapour. Level in sewer must be controlled by jetting, by-passing, etc. so that any significant occurrence or defect can be seen in enough detail for identification, including the invert of the line. The Flusher Operator and Sanitary Sewer Television Inspection Technician must contact the Employer every morning to verify their location. The Employer will supply the contact name and phone number.

The Contractor shall provide a pan and tilt type camera, or approved equivalent, to ensure a better evaluation and inspection of the pipe walls, and of leaking joints and lateral connections. The camera shall have remote focus, auto iris, min. 2 lux sensitivity, and min. 460 lines of resolution and shall be

self-propelled or skid mounted. Television equipment shall consist of a self-contained camera and a monitoring unit connected by a coaxial cable. This equipment shall be specifically designed and constructed for such inspection purposes. Picture quality shall be such to produce as a minimum a continuous 460 line resolution picture in colour showing the entire periphery of the pipe. Picture quality and definition shall be to the satisfaction of the Owner. Camera speed shall not exceed 0.1 m / second in a 200 mm diameter sewer. The camera advance rate shall not exceed 6 metres per minute to allow adequate time for operator interpretation. A uniform rate of speed shall prevail.

System inspection will progress in order based on drainage areas and as agreed during preparation of SIP. Any diversion from the order as instructed during SIP stage shall require to be supported with justification and prior approval from the Employer. The Contractor shall provide all equipment and operators required to satisfactorily perform all the work under this Contract. All operators shall be well qualified and experienced and able to readily identify all defects and deficiencies in the sanitary sewer and storm drains system.

Work shall not commence until the Employer or Employers Representative is satisfied that all items of the survey equipment have been provided and are in full working order. The Sanitary Sewer Television Inspection Technician must contact the Employer's Representative every morning to verify their location. The Contractor shall consider in his bid the cost for installing all required night lines in the sewers to enable the camera traction cable to be drawn through the sewer. Location measurement of defects shall be made by devices having a proven accuracy of plus or minus 1%.

Equipment shall be mounted in an appropriate vehicle. Electrical power for the system shall be self-contained. Sound dampening shall be applied to the vehicle and equipment. The Employer or Employer's Representative shall not be responsible for any loss or damage to the Contractor's equipment. The Contractor shall carry all necessary insurance to cover loss, damage, and/or retrieval during inspection.

The Contractor must provide adequate facilities for the Employer/Employer's Representative to view the television monitor together with the operator while the inspection is in progress. All maps and drawings required for locating the manhole chambers on the sewer lines to be inspected shall always be kept ready and accessible for carrying out this work. The Contractor shall be responsible for locating and identifying the manhole chambers and sewer lines and this data shall be the outcome of the underground utility survey conducted by the contractor during SIP. If any mismatch is found for the survey conducted during SIP stage and that during SIP implementation stag The Contractor may install plugs in the sewers to prevent the flow of sewage during inspection for a period of no longer than ten (10) minutes for any given time. Plugs shall only be installed when approved by the Employer's Representative in locations where sewer flows hinder a proper television inspection. The Contractor will be entirely responsible for any flooding that may result from installing plugs in the sewer mains.

Permanent colour thermal video prints of good quality shall be taken to show all encountered major defects in the system. The prints shall be catalogued and mounted in a suitable print file at the back of each final report. CD/DVD records of all the inspected sewers shall also be submitted with the final report and the required CCTV inspection database.

The Contractor must maintain a daily log in duplicate, showing the location of defects and a detailed description of the defect. One copy of this log must be submitted to the Employer/Employer's Representative upon completion of one day's work. The CCTV inspection shall provide a full record of

the condition of the pipes, manhole chambers, and appurtenances along the designated section of sewer. Inspect sewers to observe and record structural defects, service defects and to assess thoroughness of cleaning.

Code the sewer condition in accordance with the approved format and include the findings in an inspection report. Code all observations. Pictures shall be clear and in focus and must not be hazy due to steam or water vapour. Level in sewer shall be controlled by jetting, by-passing, etc. so that any significant occurrence or defect can be seen in enough detail for identification, including the invert of the line. All observation data must be recorded in the manner as per the approved DATA FORMAT during the SIP stage.

Final Report

The Contractor shall submit a final report within 10 days of completion of the field work. The final report shall include:

a) A detailed log of each sewer/storm drain including:

1. the location of every fault;

2. the estimated extent of the fault;

3. a recommendation on whether the fault requires immediate repair;

4. a recommendation as to what must be done to repair the fault repair including the location, extent, and repair method and materials;

The log shall be provided in a printed report form, as well as in an electronic database format on CD/DVD in accordance with the data format.

c) CCTV camera inspection videos documenting each of logged items, provided on CD/DVD in accordance with the data format.

d) Digital/Printed photographs documenting each of the logged items, provided on CD/DVD in accordance with the data format.

Video records shall display the sewer/storm drain line ID number throughout the duration of the sewer/ drain line inspection. The Report shall include a cover page listing all the inspections included in the Report. The cover page shall include sewer/ drain line ID numbers, street locations and length in metres of sewers/drains inspected. Contract tendered rates shall include and cover the cost of the Final Report. The report shall include the location of all service connections together with the statement of opinion as to whether or not the service connections are leaking. Protrusions of service connections into the main line shall be noted with reference to the degree of protrusion.

Digital photographs of all sewer/storm drain defects shall be taken and shall accompany each inspection report. Permanent colour thermal video prints of good quality shall be taken to show all encountered major defects in the system. The prints shall be catalogued and mounted in a suitable print file at the back of each final report. CD/DVD records of all the inspected sewers shall also be submitted with the final report and the required CCTV inspection database. Each manhole chamber to manhole chamber section of pipe shall be located on the report form in such a way as to be readily identifiable. Identify such items as street names, manhole chamber numbers, type of pipe, joint length, direction of flows, pipe diameter, manhole chamber depth, inspection date, names of the inspection technician, persons viewing, and video identification numbers.

Data Format

All electronic deliverables shall be delivered in CD/DVD. Depending on the size of the work, more than one CD/DVD might be required. The first CD/DVD shall contain:

1. The database file (.mdb) containing all inspection data under the work package.

2. A video file can be included here but it is not mandatory and can be part of other CDs/DVDs that are part of the package.

3. All inspection header files will include a statement of operating and structural rating. The database file (.mdb), picture files (.jpg), and all video files (.mpg) on all deliverables shall be in the root directory (no folders) of CD/DVD. The database format is generally described in the database schema that follows:

a) The database file shall be named lscl.mdb

b) The database file shall contain all final inspections ordered in the Contract. All data resulting from the contract shall be captured and stored in accordance with the following file structure, and not populated fields shall be NULL (empty).

7.39 PARTICULAR TECHNICAL REQUIREMENTS – MISCELLANEOUS

7.39.1 Contractor's Offices, Stores and Services

The Contractor shall provide, erect, construct, maintain and subsequently remove proper offices, stores, workshops, laboratories, storage and parking areas for his own use. Such facilities shall be sufficiently sized and equipped to enable him to manage his operations and those of his Subcontractors in a professional manner and to enable him to carry out all his obligations under the Contract. Sheds for storage of materials that may deteriorate or corrode if exposed to the weather shall be weatherproof, adequately ventilated and provided with raised floors. No material shall be placed directly on the ground. Within his offices a meeting room shall be available for site meetings with the Engineer and the Employer.

7.39.2 First Aid at Office and work site

The Contractor shall make his own arrangements for treatment of casualties on the Site in such first-aid units as may be thought necessary. The Contractor shall be responsible for the construction of such first-aid units and their management and operation and the removal by ambulance of injured or sick employees to nearby hospitals. The first-aid service shall cover the Contractor's own personnel as well as that of the Employer, the Engineer and all Subcontractors.

7.39.3 Testing Facilities, Laboratory

Within 21 days of issue of Notice to Proceed, the Contractor shall establish, in the campus of site office, an on-site fully furnished and adequately equipped field laboratory staffed by qualified personnel suitable for construction material testing except cement and steel etc. He will make the facility to test other material in the approved independent material testing laboratory. The name and qualifications of independent testing laboratories shall be submitted to Engineer for approval no less than thirty calendar days prior to the date the laboratories are to be used. Once approved, dismissal and replacement of the approved independent testing laboratory shall require written authorization by the Engineer. The site laboratory shall be functional till the design build work is completed. Laboratory and equipment shall become the property of the Contractor upon completion of the Contract

The calibration of the laboratory equipment and instruments shall at the initial stage to be certified by agencies approved by the Engineer. Laboratory equipment shall be properly maintained and calibrated throughout the period of the Contract by the Contractor at his own expense. The Contractor shall notify the Engineer in sufficient advance prior to conducting any tests for the materials and work. The Engineer will also inspect the laboratory and the contractor shall provide adequate facilities to the Engineer for his independent verification of the accuracy and adequacy of the facilities.

The Contractor shall be responsible for the sampling, curing, and transport to the laboratories of all materials for testing, and all testing costs including laboratory fees, and/or all costs in running the on-site laboratory, i.e., chemicals, reagents, and other test consumables, staff, and utilities.

7.39.4 Site Safety

The Contractor shall at all time in the conduct of his work and that of his Subcontractors adhere to the established rules and regulations concerning all safety matters at Site as per applicable laws.

The Contractor shall provide the public with adequate information on all risks with respect to the construction works. If the general public sustains any kind of bodily injury or death, the Contractor shall be responsible for providing all necessary medical care and compensation.

During construction the Contractor shall erect, maintain and subsequently remove sufficient barricades, guards, lighting, sheeting, shoring, temporary sidewalks and bridges, danger signals as well as temporary covering of potential accident areas, as approved by the Engineer. .

All open excavations along pipe lines shall be protected sufficiently to keep out livestock, and ensure the safety of workmen and members of the public and be in accordance with the directives of the police and the other local regulations.

The Contractor shall be responsible for ensuring that all persons working in the vicinity of powerlines are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines.

Where work is to be carried out in the proximity of buildings, bridges, tanks or other structures, the Contractor shall take all necessary precautions, including shoring and strutting, where necessary, to ensure the safety of the structures that are at risk.

The Contractor shall be responsible for all damages or injury which may be caused on any property by trespass by the Contractor's or his Subcontractor's employees in the course of their employment, whether the said trespass was committed with or without the consent or knowledge of the Contractor.

7.39.5 Protection of Overhead and Underground Services

The Contractor will be held responsible for any damage to known services (i.e. overhead services that are visible within the Site and underground services shown on the drawings or marked through survey & investigations) and he shall take all necessary measures to protect them. All work or protective measures shall be subject to approval of the Engineer. In the event of a service being damaged he shall inform the Engineer and the authority concerned, the Contractor shall not repair any such service unless instructed to do so.

Contractor will map the underground utilities. Where no underground services are shown on the drawings or scheduled but the possibility of their presence can reasonably be inferred, the Contractor shall, in collaboration with the Engineer, ascertain whether any such services exist within the relevant section of the Site. The Contractor shall complete such an investigation well in advance of the start of construction work in the said section and he shall submit a report in good time to enable the Engineer to make whatever arrangements are necessary for the protection, removal or diversion of the services before any construction activities commences.

As soon as any underground service not shown on the drawings is discovered, it shall be deemed to be a known service and the Contractor will be held responsible for any subsequent damage to it. If such a service is damaged during the course of its discovery, the cost of making good such damage will be met by the Employer unless he establishes that the Contractor did not exercise reasonable diligence and that the damage was avoidable.

Where the authority concerned elects to carry out on its own account any alterations or protective measures, the Contractor shall co-operate with and allow such authority reasonable access and sufficient space and time to carry out the required work.

7.39.6 Signboards

Signboards shall be placed at the project offices, at important locations and at each DMA zone, in English & Punjabi, information about the project and Employer, and the names of the Engineer and

Contractor in a form and size to be agreed by the Engineer. They shall be of durable construction capable of withstanding the effects of the climate until the end of the design build Period.

The Contractor shall keep the signboards in good repair for the duration of the contract and shall remove them on completion of the Contract.

Besides these signboards the Contractor shall not, except with the written authority of the Engineer, exhibit or permit to be exhibited on the Site any other form of advertisement.

7.39.7 Site Drainage

The Contractor shall keep each Section of the Works well drained until the Engineer certifies that it is substantially complete and shall ensure that, so far as is practicable, all work is carried out in the dry. Site areas shall be kept well drained and free from standing water except where this is impracticable having regard to methods of Temporary Works properly adopted by the Contractor.

The Contractor shall provide, operate and maintain in sufficient quantity such pumping equipment, well points, pipes and other equipment as may be necessary to minimize damage, inconvenience and interference and shall construct, operate and maintain all temporary coffer-dams, sumps, ditches, drains and other temporary works as may be necessary to remove water from the Site while construction is in progress. Such Temporary Works and construction equipment shall not be removed without the approval of the Engineer.

Notwithstanding any approval by the Engineer of the Contractor's arrangements for the removal of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times and for making good at his own expense any damage to the Works.

The Contractor shall be responsible to keep the Site clear of water at whatever pump rate is found necessary.

The Contractor’s site drainage facilities shall not cause pollution in any local watercourses, he shall be responsible for any legal action resulting from pollution events.

7.39.8 Detours and Traffic Control

The Contractor shall program his work in such a way that, wherever the temporary closure of street sections to public thoroughfare cannot be avoided, the duration of traffic diversion can be kept as short as possible. No streets shall be closed and no detours shall be introduced and no traffic diverted until the Contractor's proposals have been approved by the Engineer and the appropriate Government authorities.

Where work is to be carried out in public roads, the Contractor shall give notice to the Engineer sufficiently in advance of the date on which he wishes to commence such work.

The Contractor shall be responsible for obtaining the permission of the Engineer, Road Department and the Police for activities he intends to carry out in public roads. Two copies of the Contractor's proposals to the relevant authorities shall be submitted to the Engineer. One copy of all obtained approvals shall be submitted to the Engineer.

Detours shall be selected in such a way that the inconvenience to the affected traffic as well as to the inhabitants of the affected areas is kept to a minimum.

The Contractor shall furnish, install and maintain at all times during the execution of the Works all necessary traffic signs, barricades, lights, signals and other traffic control devices, including flagging

and other means of guiding traffic through the work zone. Traffic control shall be managed in accordance with prevailing rules and regulations, and with the approval and to the satisfaction of the Engineer.

All devices mentioned above shall be in conformity with the requirements of the Roads Department. All traffic signs and control devices to be furnished and installed by the Contractor shall be approved by the Engineer for their location, position, visibility, adequacy and manner of use under specific job conditions.

All traffic control devices necessary for the initial stage of construction shall be properly placed and operational before any construction is allowed to start. When work of a progressive nature is involved, the necessary signs shall be moved concurrently where they are needed.

If the Engineer determines that proper provisions for safe traffic control are not being provided or maintained, he may restrict construction operations affected by such defective signs or devices until such provisions are established or maintained, or may altogether order suspension of the Work until a proper traffic control is achieved. In case of serious or willful disregard by the Contractor of the safety of the public or his employees, the Engineer may take necessary steps to rectify the situation and deduct the cost thereof from monies due or becoming due to the Contractor. The Contractor shall be responsible for all resulting delays.

The Contractor shall designate or otherwise employ personnel to furnish continuous surveillance of the traffic control operations. The designated personnel shall be available day and night to respond to calls involving damage due to traffic accidents.

At sections where traffic is in operation and when ordered by the Engineer, the movements of the Contractor's equipment from one place of work to another shall be subject to traffic control. Spillage resulting from hauling operations along or across the road way shall be removed immediately at the Contractor's expense.

The cost of traffic control is deemed to be included in the rates for works.

7.39.9 Provision of Temporary Services

When the execution of the Works requires the temporary disconnection of existing public utilities, the Contractor shall provide the affected users with temporary services in at least the same standard as the original services.

For water supply he may install temporary lines or arrange for regular supply by tankers. The amount of water to be provided for the interruption period for a specific area shall be assessed by the Contractor. The Contractor shall submit to the Engineer, for its approval, the recommended volume of water to be provided.

When forced to disconnect existing sewers/drainage facility, the Contractor shall install temporary pipes of adequate size to carry off sewage/drainage. No sewage/driange shall be allowed to flow upon the ground surface or into the trench excavation.

No valve or other controls in public service facilities shall be operated by the Contractor without approval of the Engineer and the relevant authorities. All users affected by such operation shall be notified by the Contractor at least two hours before the operation and advised of the probable time when service will be restored.

7.39.10 Protection of Adjoining Property and Reinstatement upon Completion

The Contractor shall be responsible and take all measures in order to protect adjoining property including buildings, electrical and telephone poles, bridges and culverts, retaining walls, compound walls and fences, and other structures. Prior to the commencement of the activities, the Contractor shall assess the probability and extent of unavoidable damages, if any, to the building and properties and submit his assessment to the Engineer. The Engineer may make his own opinion and if required may order arrangements for protection or repair of such likely unavoidable damage in which event the Contractor shall complete the activities.

Temporary facilities shall be provided by the Contractor, only for as long as required after which he shall dismantle and remove the same from their place of use as speedily as possible. Re-usable components shall be safely stored by the Contractor in his yard. The place of use shall be cleared and reinstated immediately to at least the condition existing before the temporary facilities were provided, and to the satisfaction of the Engineer.

7.39.11 Coordination with Other Authorities

i. Statutory Services

As far as possible the Contractor shall acquaint himself with the actual location of all existing public utilities such as sewers, water mains, drains, cables for electricity, telephone lines, lighting poles, masts, etc., before commencing any activities likely to affect the existing utilities. The Contractor shall with the assistance of the Employer obtain such information directly from the responsible authorities as early as possible.

ii. Notices, Permits

Well in advance of the programmed start of any work which may affect traffic or any existing utilities the Contractor shall give advance information to the Employer/Engineer indicating the type, the exact location, the programmed starting time and the expected duration of the activities and shall provide whatever particulars may be required by the authorities to issue any required permits and make all necessary arrangements. The Employer will provide necessary permissions.

7.39.12 Submissions by the Contractor

i. Pre-Construction Surveys and Setting Out

The Contractor shall verify all measurements and be responsible for their correctness. Site bench marks shall be accurately and safely established, maintained and removed upon completion of the Works, all to the satisfaction of the Engineer. The Contractor shall prepare a plan detailing the location of the bench marks and keep this up-to-date throughout the period of the Contract. Reproducible copies of the plan so prepared shall be supplied to the Engineer, as and when he may require.

The Engineer reserves the right to order levels, considered necessary for the full and proper supervision and measurement of the works, to be taken at any time.

Before the Works, or any part thereof, are commenced, the Contractor and the Engineer shall together make a complete survey, and take levels, of the Site and agree on the dimensions and elevations upon which setting out of the Works shall be based.

These levels shall be related to the bench marks and shall be plotted and drawn up by the Contractor. After agreement of the drawings, which shall be signed by the Engineer and the Contractor, these levels shall form the basis of setting out of the Works.

The Contractor shall be responsible for the true and proper setting out of the Works in relation to reference data given on the Drawings and shall accurately set out the positions, levels and dimensions of all parts of the Works. Any delay or loss resulting from errors in the setting out of the Works shall be the responsibility of the Contractor.

Setting out shall be reviewed by the Engineer before commencing the Works, but any approval shall, in no way, relieve the Contractor of his responsibility for the correct execution of the Work.

ii. Working Drawings

The proposals shown on the tender drawings are based on information available prior to preparation of the Tender Documents. All levels indicated or proposed are based on survey information previously available but will need to be revised subject to the results of survey and site investigation carried out by the Contractor during SIP.

Working Drawings of the designs carried out by the Contractor shall be submitted by the Contractor to the Engineer. Working Drawings shall include, but not be restricted to, pipeline plans and profiles, reinforcement detail drawings and bending schedules, shop drawings for structural steel and miscellaneous metal work, and drawings for other work for which the Engineer's approval is required.

It shall be the Contractor's own responsibility to prepare such Working Drawings as he may require for the proper setting out and construction of all structures and facilities. Work shall not commence on an individual structure or facilities until the relevant Working Drawings have been approved by the Engineer.

All dimensions shall be in metric units and each drawing shall be properly identified by a drawing head and a numbering code in the form prescribed by the Engineer upon commencement of the Works.

The Contractor shall submit 3 (three) copies of all drawings for approval.

Any changes or modifications to the Working Drawings that the Engineer considers necessary shall be made by the Contractor promptly and the drawings resubmitted for approval.

Approval of Working Drawings will be given by the Engineer in the form of a stamp "RELEASED FOR CONSTRUCTION" together with the date and the authorized signature. Only those Working Drawings carrying the signed and dated stamp shall be used for execution.

Copies of all such approved Working Drawings together with one unreduced transparency shall be supplied to the Engineer by the Contractor immediately after approval. The cost of preparing and providing all Working Drawings shall be included in the Contract Rates.

Should it be found at any time after approval has been given by the Engineer to a Working Drawing submitted by the Contractor that the said Working Drawing does not comply with the terms and conditions of the Contract or that the details do not agree with the Working Drawings previously approved, such alterations and additions as may be deemed necessary by the Engineer shall be made therein by the Contractor and the work carried out accordingly without entitling the Contractor to extra payment on account thereof, except where such alternations and additions are to be made in direct consequence of written order by the Engineer to vary the Works.

No examination by the Engineer of any document submitted by the Contractor or of the Contractor's Working Drawings, nor the approval expressed by the Engineer in regard thereto, either with or without modification, shall absolve the Contractor from any liability imposed upon him by any provision of the Contract. Notwithstanding the Engineer's approval of the Working Drawings the Contractor shall be responsible for any dimensional or other errors.

iii. As-Built Drawings and GIS Data Creation

Such approved Working Drawings as have been selected by the Engineer shall be correctly modified for inclusion in the As-Built Drawings incorporating such variations to the Works as have been ordered and executed. Such drawings shall show the actual arrangement of all structures and items of equipment installed under the Contract. The Contractor shall submit 1 (one) reproducible copy and 3 (three) prints of all As-Built Drawings clearly named as such to the Engineer for approval before applying for the Taking-Over Certificate for the respective Section of the Works. After approval of the As Built Drawing the Contractor shall supply an electronic copy of the drawing in together with a licensed copy of the drafting software.

During the course of the Works, the Contractor shall maintain a fully detailed record of all changes from the approval to facilitate easy and accurate preparation of the As-Built Drawing.

Irrespective of the other contractual prerequisites no Section of the Works will be considered substantially completed until the respective As-Built Drawings have been approved by the Engineer.

In parallel with the preparation of as-built drawings, the Contractor shall produce GIS data of the constructed works. The contractor conducts all necessary survey work, and shall ensure that vertical and horizontal measurements shall be captured at an accuracy of +/- 0.1m at a 95% confidence level, using the most suitable and cost-effective field data collection technology and methodology. All horizontal and vertical survey measurements will be referenced to the present Survey of India GIS geo reference.

The Contractor will survey the three-dimensional position (x,y,z) of all point and line assets constructed under this project, e.g., pipelines, bridge crossings, manhole chambers, chambers, valves, meters, hydrants, plugs, reducers, and tees. Nodes shall be created to clearly delineate different pipe sections in terms of material and/or diameter and to allow for future development of a hydraulic model in the GIS platform. Nodes shall also require a three-dimensional position, and through this, the position of the ends of a pipeline segment shall be defined. Point and line data (i.e., the pipeline) should be consistent with the attributes of the existing Survey of India GIS. However, the Engineer and the Employer may require the Contractor, at no additional cost, to create new attributes to include non-survey data, e.g., valve model, name of the manufacturer, images or plans, etc. Prior to the field survey, the Contractor shall submit to the Engineer, for approval, the GIS design in terms of themes, feature types and attributes.

The Contractor shall develop a checklist of QC checks for each type of deliverable and will be responsible for ensuring that these QC checks are performed. The Contractor shall assign a GIS quality officer to manage the quality review process. This officer shall be independent of the capture and production teams.

The Contractor shall be required to integrate the GIS deliverables with the existing pipe network data, i.e., ensure that the GIS data connects with any existing GIS system. This may entail revising GIS

data of existing pipes at connection points. GIS data for the project will be delivered in an ArcGIS compliant file geo-database.

7.39.13 Construction Program and Progress of Works

i. Construction Program

Contractor shall prepare Construction Program as part of SIP. Construction Program shall be in the form of a Critical Path Method (CPM) Diagram showing, sequences, dependencies, durations and dates for execution of all major items including sectional completion following the sub-divisions in the Bills of Quantities for the execution of the Works within the periods stated in the Contract. It shall be supported by:

a. Data of the construction methods

b. Equipment Utilization Schedule

c. Manpower Utilization Schedule

d. Subcontracting Schedule

e. Mobilization/Demobilization Schedule

The CPM diagram incorporating the above mentioned schedules shall be prepared using Microsoft Project, or similar approved project management software, and shall be presented in hard copy and electronic form to the Engineer as part of SIP.

In carrying out the Works due attention shall be paid to all measures which can reasonably be taken in order to diminish the inconvenience which the work may cause to services and access to property.

7.39.14 Updating, Monitoring and Reporting Progress

The Contractor shall monitor the progress of the Works including information provided by his Sub-contractors and suppliers, as necessary, for purpose of network planning, scheduling and updating and shall confirm the actual progress on each current activity shown on applicable CPM networks. The CPM networks shall form part of the Monthly Progress Report and shall indicate changes of schedule, if any in network activity duration and start/finish imposed dates. It shall also be provided in electronic form.

The Contractor shall prepare written explanatory notes on the particular activities which are overrunning or going to overrun against the schedule. If any such overrunning work is on the critical path, the Contractor shall state what corrective actions will be taken by him to bring it back on the schedule.

i. Detailed Fortnightly Program

The contractor shall submit at the end of each working week a detailed bar chart program for the next fortnight. The program shall identify where further drawings or instructions are to be issued by the Engineer to avoid disruption to the progress of the Works.

ii. Progress Reports

The Contractor shall furnish the Engineer with 5 copies of Progress Reports at regular monthly intervals in a form determined by the Engineer, containing the following information:

- physical progress for the report month and estimated progress for the next month;

- CPM networks and explanatory notices ;
- updated S-curves for physical progress at different sections of the Works
- any report which may be specifically requested by the Employer and/or the Engineer.

These monthly progress reports shall be submitted not later than 7 days after the end of the report month.

iii. Operation and Maintenance Manual

The contractor will submit an operation and maintenance manual, providing details of all the plant/ mechanical facilities (valves, meters, etc.) he supplies and give details of recommended maintenance intervals and procedures.

iv. Record / Progress Photographs

The Contractor shall arrange each month sufficient number of photographs as Record Photographs of progress of works and shall provide the electronic files. Contractor will include progress photos in the progress reports.

7.39.15 Quality Control

i. Quality Control Plan and Procedures

The Contractor shall be responsible for establishing and maintaining procedures for quality control that will ensure that all aspects of the Works comply with the requirements of the Contract.

As soon as reasonably practicable prior to the commencement of Works the Contractor shall submit for approval a Quality Control Plan giving detailed proposals for control of quality of all aspects of work on the Site and at suppliers' workshops.

The Quality Control Plan shall include the following: a) a list of the Contractor's staff engaged in quality control b) a list of any outside testing agencies employed by the Contractor for work in connection with quality control c) where a testing laboratory is to be established on Site under the Contract, a list of major items of equipment and a layout of the laboratory, together details of the tests which will be carried out there d) a list of manufactured items and materials, obtained by the Contractor for the Works, which require inspection at the suppliers' premises, and the proposed procedures for ensuring quality control e) a list of materials and operations to be inspected by the Contractor at the various stages of construction work on Site, together with inspection procedures, test types and frequencies f) sample of proposed quality control records, testing and reporting forms.

Unless the Engineer permits otherwise, the approved Quality Control Plan shall be followed throughout the construction of the Works. Any approval by the Engineer of the Contractor's plan and procedures shall not relieve the Contractor of his obligation to ensure that the Works comply with the requirements of the Contract.

The Contractor shall appoint a suitably qualified member of his staff to be responsible for all aspects of quality control and to maintain effective liaison with the Engineer.

ii. Sampling and Testing

The Contractor shall provide for the approval of the Engineer, samples of all construction materials and manufactured items required for the Permanent Works. All samples rejected by the Engineer

shall be removed from Site. All approved samples shall be stored by the Contractor in a sample room, at a location approved by the Engineer, for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation in the Permanent Works shall be of a quality at least equal to the approved sample. The approved samples may only be disposed of with the Engineers approval.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer. Samples for testing will generally be selected by the Engineer from materials to be utilized in the project and all tests will be under the supervision of, and as directed by, and at such points as may be convenient to the Engineer.

Material requiring testing shall be furnished in sufficient time before intended use so as to allow for testing. No materials represented by tests may be used prior to receipt of written approval of said materials.

The Contractor shall give the Engineer 3 to 7 days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the suppliers' premises or at a laboratory approved by the Engineer and unless the Engineer shall attend at the appointed place and time the test may proceed in his absence. The Contractor shall in any case submit to the Engineer within 3 days after every test such number of certified copies of the test readings as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provisions of this Clause shall also apply to materials supplied under any nominated subcontract.

After all construction at each Section is completed and before applying for taking-over, the Contractor shall perform field tests as called for in the Specifications. The Contractor shall demonstrate to the Engineer the proper operation of the facilities and the satisfactory performance of the individual components. Any improper operation of the system or any improper, or faulty construction shall be repaired or corrected to the satisfaction of the Engineer. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make the same comply with the Specifications, or replace any defective parts or materials.

In addition to any special provision made herein as to sampling and testing materials by particular methods, samples of materials and workmanship proposed to be employed in the execution of the Works may be called for at any time by the Engineer and these shall be furnished without delay by the Contractor at his own cost. Approved samples will be retained. The Engineer will be at liberty to reject all materials and workmanship that are not equal or better in quality and character than such approved samples.

The tests required for quality control shall include but not be limited to:

a) tests conducted at the premises of the Contractor, Subcontractor, manufacturer or supplier which are normally or customarily carried out at such premises for the items or materials being supplied for the Works

b) tests which are normally or customarily conducted on the items or materials being supplied for the Works by the Contractor, Subcontractor, supplier or manufacturer but which have to be conducted at an approved laboratory because the necessary testing facilities are not available on the premises of the Contractor, Sub-Contractor, supplier and manufacturer

c) tests on locally obtained materials or items either on the Site or at an approved laboratory for the purpose of obtaining the approval of the Engineer to the classification, use and compliance with the Specifications of such items or materials

d) routine quality control tests conducted by the Contractor to ensure compliance with the Specifications e) regular testing of concrete and other materials as specified in the relevant Chapters of the Technical Specifications f) standard shop and Site acceptance tests, including trial assemblies, of Plant.

iii. Inspection and Acceptance

The Engineer will not inspect any item of fabricated or finished work until such time as the Contractor shall have forwarded to the Engineer the approved Working Drawings covering the items to be inspected, together with copies of the respective orders.

Manufactured items and materials delivered to the Site shall be inspected by the Contractor on arrival. Any defects shall be notified to the Engineer.

Minor defects to surface finishes and the like in manufactured items shall be made good in an approved manner to the satisfaction of the Engineer. Items with more serious defects shall be returned to the suppliers for correction or replacement as appropriate.

iv. Materials/ Plant Certificates and Inspections

Where certificates are required by the Specifications or relevant Reference Standard, the original and one copy of each such certificate shall be provided by the Contractor.

Certificates shall be clearly identified by serial or reference number and shall include information required by the relevant Reference Standard or Specification clause.

The timing for submittal of certificates shall be as follows:

a) manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than 7 calendar days prior to the time that the materials represented by such certificates are needed for incorporation into the Permanent Works

b) certificates of tests carried out during the construction or on completion of parts of the Permanent Works shall be submitted within 7 days of the completion of the test.

No materials, articles or items of fabricated or finished work to be supplied by the Contractor or Subcontractors which have been inspected and tested by the Engineer or the inspecting Engineer shall be dispatched unless a Passing Certificate has been requested by the Contractor from the Engineer and subsequently been issued by the Engineer to the effect that the same are approved. Neither the Contractor nor Sub-Contractors shall make use of any materials or articles ordered by them for the purpose of fabrication until a Passing Certificate covering the said materials and articles shall have been issued by the Engineer or inspecting Engineer.

7.39.16 Site Records

Daily records of on-site testing and inspection shall be kept on forms of approved format. Test results shall be certified by the responsible member of the Contractor's staff. All test certificates and inspection records (including any from suppliers or other outside testing agencies) shall be clearly

identified with the appropriate part of the Works to which they refer, and they shall be submitted to the Engineer together with the respective Passing Certificate.

Once each month, or at such other intervals as the Engineer may require, the Contractor shall submit in an approved form a summary of all quality control inspections and tests performed at Site and elsewhere in the intervening period.

Test results shall be summarized in tabular form or graphically or both in a way that best illustrates the trends, specific results and specification requirements. Where the tests show that the specified requirements were not achieved, the report shall describe the action that was taken.

Each report shall also contain a forecast of quality control work likely to be carried out during the period to be covered by the succeeding report.

The Contractor shall keep detailed and up-to-date inventories in an approved form of goods and materials already approved by the Engineer for which Passing Certificates have been issued as well as of all other goods and materials subject to quality control which are on order, delivered, found faulty, lost during the work or found to be surplus to requirements. The Engineer shall have access to these records at all times.

7.39.17 Separation of Water and Sewer lines

The issue of relative placement of the water line and sewer in relation to possibilities of pollution should also be paid attention. The provisions of the Manual of Water Supply be followed in the matter. Accordingly broadly the following may be followed:

Horizontal Separation:

- Desirable 3 m separation
- In case of local compulsions, it may be laid in a separate trench on a shelf closer to the sewer but 0.5 m above the top of the sewer

Vertical Separation:

- In case of crossings, the water main should be 0.5 m above the sewer top or drain for 3 m on either sides and should have joints as far as possible.

7.39.18 Water Tightness Tests for the Reservoirs:

In addition to the structural test of structures, the newly constructed reservoirs shall also be tested for water tightness test at full supply level as described in latest revision of IS 3370 (Part I).

On completion of the Service Reservoir works and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of Service Reservoir is done and when it is possible to fill the reservoir and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before starting of the filling operations, the reservoir shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for

ventilation and lighting of the reservoir by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Engineer. For this purpose, it shall be verified that sluice valves provided on the various pipes connected to the reservoir then shall be carried out gradually at the rate not exceeding 30 cm rise in water level per hour. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The reservoir once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the reservoir, which for all practical purposes shall not exceed 40 mm. Also there shall be no indications of the leakage around the puddle collars or on the walls and bottom of the reservoirs.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and it the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. Contractor shall have to make arrangement for filling emptying the reservoir at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned and the Contractor will dismantle and reconstruct the structure, to the original specification, at his own cost. During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the rates quoted of different items of work of Service Reservoir.

Precautions to keep Service Reservoirs free from Contamination

As soon as possible after completion of reservoir and after its pipes have been laid the Contractor shall remove all dirt, debris, materials, tools etc. from the reservoir and shall wash and brush down with water the whole of the interior. He shall also if required by the Engineer incorporate a mixture of chloride of lime in the water wash required.

The greatest care shall be taken to keep the entire reservoir free from any contamination. Strict supervision shall be maintained over the workmen entering after first washing down. Provision shall be made to enable workmen to wash their feet or footwear clean and sterilize them before entering.

7.39.19 Testing, Disinfecting and Rinsing of Water Pipelines

7.39.19.1 General

All pipelines and all works shall be subject to pressure and leakage tests after being laid and installed before commissioning.

Pressure and leakage tests shall be carried out simultaneously. Provisions of this clause shall be read in conjunction with the provisions for testing and disinfection of pipes under IS: 3114, IS:12288 and other Indian Standard Specifications as applicable.

The Contractor shall provide all equipment, material and labour necessary for carrying out testing and cleaning including pumps, gauges, pipe connections, stop ends and all other temporary works. Contractor shall remain entirely responsible for the care of the works during testing and cleaning of the pipelines.

7.39.19.2 Hydraulic tests for pipeline

After laying and jointing, the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, isolation valve, and other chamber). At the beginning, the contractor shall test stretches not exceeding 2 km.

After successful organization and execution of tests the length may be extended to more than 2 km after approval of the Engineer. The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol, if required:

- Complete setting of the thrust blocks
- Partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- Opening of all intermediate valves (if any)
- Fixing the end pieces for tests and after temporarily anchoring of these against the soil (not against the preceding pipe stretch)
- At the lower end with a precision pressure gauge and the connection to the pump for establishing the test pressure
- At the higher end with a valve for air outlet
- If the pressure gauge con not be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly
- Slowly filling the pipe from the lowest point(s)
- The water for this purpose shall be reasonably clear and free of solids and suspended matter

- Complete removal of air through air valves along the line
- Closing all air valves and scour valves
- Slowly rising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring
- Keeping the pipeline under pressure for the duration of the pre-test/ saturation of the lining by adding make – up water to maintain the pressure at the desired test level. Make up water to be arranged by Contractor himself at his own cost.
- Start the test by maintaining the test pressure at the desired level by adding more make up water; record the water added and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.
- Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches.
- The testing conditions for the pipelines shall be as per the test pressures and condition laid out in IS: 8329 for DI pipes and IS: 7634 (Part II) for HDPE pipes.
- The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits, No section of the pipe work shall be accepted by the Engineer until all requirements of the test have been obtained.
- Pre test and saturation period with addition of make-up water

  Pressure: Test Pressure

  Duration: 3 hrs for pipes without cement mortar lining / 24 hrs for pipes with cement mortar lining

- **Test criteria for DI pipes:**

  Pressure: Test Pressure

  Duration : 3 hrs Q = 1 litre per km per length per 10mm diameter of pipe per 30m test pressure per 24 hrs.

- **Test criteria for HDPE/ uPVC pipes :** Q = 1.125 litre per km per 10mm diameter of pipe per 30 m test pressure per 24 hrs.

No pipe installation shall be accepted until the leakage is less than the amount 'Q', as determined by the above formula:

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount 'Q', calculated by the above formula. Where any test of pipe laid indicates leakage greater than that specified as per the above formula, the defective pipe(s) or joints(s) shall be repaired/replaced as per the satisfaction of engineer in charge until the leakage is within specified limits. The Contractor has to make his own arrangements for water of approved quality, required for testing pipeline

The table, hereunder, gives recommended test pressure for HDPE/DI pipes.

Table 24: Recommended Test Pressure for HDPE/DI Pipes

Maximum Continuous Working Pressures and Recommended Test Pressures		
Class of pipe	Working Pressure	Recommended Site/ Field Test Pressure
	Kg/ sq cm	Kg/ sq cm
HDPE pipes	6.0	9.0
DI Class K-7/K- 9/MS	As per pipe size & up to 45 kg/sqcm	2xmaximum design pressure (with minimum design pressure as 6.0 kg/sqcm)

If it is required to test a section of a pipe line with a free end, it is necessary to provide temporary support against the considerable end thrust developed by the application of the test pressure. The end support can be provided by inserting a wooden beam or similar strong material in a short trench excavated at right angle to the main trench and inserting suitable packing between the support and pipe end.

7.39.19.3 Failure to pass the test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to the unsatisfactory in any way shall be redone by the Contractor.

7.39.19.4 Cleaning Out After Testing

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed. All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the contractor.

After the completed pipeline is tested, approved, backfilled and the Contractor has removed all temporary works and has reconnected any parts temporarily removed from the pipeline, the Contractor shall finally clean out the whole pipeline and flush it through with water.

7.39.19.5 Disinfection

After cleaning out, disinfection shall be performed in the following manner: after flushing the pipes the system shall be drained completely, all valves shall be closed carefully and the system filled with a strong chlorine solution of about 50 ppm free chlorine. This solution shall remain in the system for a period as directed but not exceeding 24 hours uninterruptedly. Chlorine residual tests shall be done at various points by an orthotolidine reagent with a colour scale. The disinfection process shall be repeated until the chlorine residual is not less than 10 ppm at all sampling points. After disinfection the entire pipeline shall be rinsed with potable water till the chlorine residual is less than 4 ppm at various points of testing.

After completion of disinfection and rinsing the results shall be reported by the Contractor in writing and signed by the Contractor and the Engineer.

The Contractor shall provide at his own expense such sampling points as the Engineer may direct if permanent points are not available or suitably located.

7.39.19.6 Water for Testing and Cleaning

The Contractor shall provide all water required for testing, cleaning and disinfection of the pipeline at his own cost and shall use only potable water. Contractor shall also bear the cost of chemical required for disinfection.

Disposal of water after testing, disinfection and cleaning shall be arranged by the Contractor with prior approval from the Engineer. The disposal shall be done in such a manner as will not cause any harm to any standing crop, cultivated land, damage to roads or structures, cause submergence and/or nuisance to any public or vehicular traffic.

7.39.19.7 Testing and Commissioning

After successful sectional tests after pipe laying and other pre-commissioning tests after physical completion, the pipeline shall be commissioned by the Contractor. Dynamic commissioning shall be made in conjunction with or after the commissioning of the respective system.

Complete supplying, laying, jointing, testing and commissioning of the pipeline works are included in the contract package and Contactor will make all necessary arrangement for complete commissioning of the transmission pipeline system when the pump sets feeding the pipelines are installed and yard piping works for respective service reservoir complexes are complete and ready. Such coordination with the other Contractors and ensuring availability of required personnel and necessary equipment for such commissioning will have to be provided by the Contractor in consultation with and to the full satisfaction of the Engineer.

During testing/commissioning, the Contractor shall supply all material and labour to supervise, adjust, test, repair and do all things necessary to maintain the testing/commissioning. This shall include labour on a 24 hour-a-day basis during the test period and for such other period of continuous operation as the Engineer may consider necessary to establish the efficient operation of the cluster distribution system.

If any test result shows noticeable variation from the specification requirements for the system the Contractor shall immediately take steps to rectify the deficiency without any extra cost to Engineer.

The Contractor shall test and commission the system for 7 days at a stretch, from the date of commissioning. On expiry of this period the system shall be taken over by the Engineer and a taking-over certificate shall be issued by the Engineer, provided all defects and/or deficiencies noticed are rectified to the satisfaction of the Engineer.

7.39.19.8 The main indicators for the successful commissioning are:

a) No leaks in pipes, joints, locations of specials and valves,

b) All valves are properly installed and operational,

c) Execution of the entire work including finishing according to the drawings and specifications,

d) Submission of “As built” drawings both in soft copies and hard copies

7.39.20 Particular Specifications – Operation Service

7.39.20.1 Standard Manuals governing in project construction and operations

The specifications and requirements for operation services shall be carried out as per Employer's requirement and shall confirm to all the relevant guidelines, standards, standard operating procedures detailed in the relevant Standards Codes published by Bureau of Indian Standards and shall be in conformity to the Manuals on Water Supply and Sewerage published by Government of India.

Where the requirement of any such standard specification or regulation conflict with Employer's Requirements, then the Operator should refer to the Technical Auditor for clarification.

7.39.21 Standard Operating Procedures (SOP)

Operating instructions and Standard Operating Procedures (SOP) shall be formulated by the Contractor for all the water supply, sewerage & storm water drainage system, component, equipment etc comprising of process equipment schedules, operation & maintenance data, sampling and analysis with frequencies etc. The operating parameters shall be optimized based on the data collected on commissioning of the facilities. All the activities in the preventive maintenance schedule shall be followed without any lapse. Indicative functions that are expected to be performed at each site are given below:

i. Water pumping stations and transmission main

i. Check operation of all pumps

ii. Take all relevant meter readings at times of the day, as agreed with the Employer

iii. Ensure compliance with agreed withdrawals from Sidhwan canal and to bring in notice of the Employer any short withdrawal.

iv. Check operation of all valves along the transmission mains

v. Flow and pressure measurement

vi. Checking operations of electrical & mechanical equipment

vii. Check the power factor and power consumption

viii. Check distribution of flows in DMAs feeder mains

ix. Test clear water samples for physical and biological quality parameters

x. Arrange the liquid chlorine and supervise proper operation of chlorination system including proper storage, handling and maintain an inventory

xi. Bring to notice of Employer any variation in drawl by each of the feeder or distribution reservoirs, which is beyond the Operator's ability to control promptly

ii. Supply Network

i. Take all relevant meter, flow and pressure readings

ii. Check operation of all equipment

iii. Check integrity of feeder mains and UGSRs

iv. Periodically check water meters and take monthly readings

v. Check for Chlorine residual, flow and pressure at the Critical Measurement Points (CMPs)

vi. Checking operations of electrical & mechanical equipment

iii. Non Routine Duties

In addition to the routine operational tasks in the process, the Operator shall undertake the following non-routine and maintenance tasks.

i. Carry out minor maintenance and repair works

ii. Emptying the tanks and periodic cleaning

iii. Site audits and surveys

iv. Test alarms

v. Safety and process risk assessment

iv. Maintenance and Repairs

A properly designed water system shall be capable of delivering desired output at all times..

To ensure the desired output at all times, a proper maintenance management plan shall be formulated, which shall have following arrangements:

i. Routine inspection and maintenance of all equipment

ii. Planned and scheduled maintenance (preventive)

iii. Unscheduled maintenance (breakdown)

iv. Cost and budget planning

v. Routine Inspection and Maintenance of Equipment

Operator shall carry out routine monitoring of the equipment and ensure that the equipment is properly maintained to meet the desired output. Typical tasks that shall be undertaken are:

A. Mechanical

i. Checking the lubrication and necessary follow-up

ii. Replacing of glands that are leaking

iii. Servicing as per supplier's instructions

iv. Stripping down of pumps to observe clogging if any

v. Checking for unusual vibrations and noise

B. Electrical

i. Checking electrical contacts and wiring

ii. Checking motor heating and noise level

iii. Assessing efficiency of electrical equipment

C. Instrumentation

i. Cleaning and calibration of probe / sensors

ii. Fault diagnosis

These maintenance tasks shall be issued on a weekly basis through computer aided management system and the Operator shall incorporate it in operating work schedule. All observations shall be recorded in the properly designed record system and would be analyzed for initiating corrective actions, if any.

vi. Planned and Scheduled Maintenance (Preventive)

A work schedule chart listing identification of critical equipment, work assignment, timing shall be prepared. Critical equipment is defined as those items where failure would adversely affect the quality and quantity of output or those that risk the safety of employees or customers. The schedule shall identify the responsible person / agency who shall be intended to complete the task e.g. in - house technician or specialist contractor etc.

The overall yearly plan schedule shall be issued to all parties to enable forward planning of anticipated manpower requirement and equipment down time. The indicative maintenance schedule of the various equipment provided in the project would be finalized during the preparation of the O&M manual.

vii. Breakdown Maintenance

The aim of routine and preventive maintenance is to keep breakdown to minimum for items of critical equipment which shall directly affect the performance. However certain breakdown may occur in spite of proper maintenance. The Operator shall take the breakdown maintenance on a top priority to keep disruption to the systems at a minimum level.

The Operator shall have an option to call other available staff and also the services of the local skilled during the breakdown period.

viii. Sub-Contracted Service

Additional resources to support the Operator with more specialized skills or where the maintenance and routine jobs required more skills than those available in-house shall be carried out through suitable sub-contractor services at the responsibility of the operator.

ix. Spare Parts

The Operator shall store spares of all the critical equipment on respective Sites and the inventory shall be assessed according to anticipated usage and in conformity with Annual Operating and Maintenance Plan. The Operator shall make available specialized spares as necessary.

x. Maintenance Reports

To assist in the management of the maintenance activities, a Computer Aided Maintenance Management (CAMM) shall be implemented by the Operator which shall be integrated with the Management Information System. This shall incorporate features such as Facility details, maintenance history records and scheduling of maintenance activities. The use of such package shall allow the Operator to predict when the maintenance activities shall need to be carried out.

Record of maintenance jobs carried out shall be reported in the record system, which shall provide the Employer the past history, time and cost involved for each category. The report shall include:

i. Details of number of jobs completed

ii. Frequency of breakdown, time required repairing and costs involved.

iii. Personnel involved / contractors used

Input data along with the base data and license, if assignable, would be made available to the Employer.

Laboratory

A laboratory equipped to perform all quality control, sampling, testing and analysis of water and sewage samples as required under this contract will be set up by Operator. All equipment including glassware and instruments, all consumables for undertaking the water quality surveillance shall be the responsibility of the Operator under this Contract.

Workshop

All the equipment and necessary tools required for carrying out in house repairs and maintenance, troubleshooting, maintenance for smooth operations will be made available by the Operator for managing the day to today repairs, maintenance etc under this Contract.

xi. Sampling, Testing, Reporting Requirements

Sampling and Analysis

The Operator shall collect all samples relative to the system required by Applicable Law and undertake physio-chemical and bacteriological analysis and provide and submit in a timely manner all such test results to the Employer. Table below set out the sampling and analysis frequencies for the Water Distribution System

Table 25 :Sampling and Analysis Schedule for Potable Water

Location	Parameters	Frequency
At the CWR/UGSR	Residual Chlorine and turbidity	Continuously logged online
At Service Reservoir Inlet and Outlet	Flow	Continuously logged online
Main flow meter at all Feeder Mains	Pressure, Flow	Continuously logged online
Distribution networks - 2 locations of customer taps randomly selected in each DMA	Residual Chlorine and terminal pressure	Daily Once

xii. Management Information System (MIS)

The Operator shall establish, develop and maintain a Management Information System (MIS). The MIS shall have capabilities for facility management, inventory management, billing management, operational job management and records and data management as well as all capabilities necessary for safe and efficient management, operation and maintenance of the Facilities.

xiii. Key Objectives

The key objectives are:

A. Capability: The proposed MIS shall be capable of handling at least 10,000 customer records with ability to expand to 20,000 to record, monitor and report on all core business activities of the Operator in connection with the services and obligations under this Contract.

B. Modules: The MIS shall have integrated modules for (1) record and monitoring the customer complaints, redressal (2) billing system, (3) keep an accurate asset registry of the water supply. Sewerage & storm water drainage infrastructure, (4) manage all accounts related to the water & sewerage services and (5) record all operational data for monitoring efficacy and efficiency of the water, sewerage & storm water drainage services.

xiv. Scope of Work

The scope of work given below is the minimum output expected from the Operator. The Operator may suggest changes to the proposed methodology and work plan to achieve the desired results. Deviation from the given specification/requirement shall be only with better specifications and the Operator shall take approval from the Employer.

A. Customer Services – shall be a simple database management system for recording customer complaints like no water, less water, low pressure, poor quality water, leakage, wrong bills, no bills etc and facilitating monitoring the complaint until its redressal by the Operator and closing the loop when the complaint is resolved or upgrading the status of complaint to higher authorities etc;

B. Billing– a comprehensive billing system capable of managing the existing customer records, cumulative metered consumption details, prevailing tariffs and process and generate a bill on volumetric tariff or on flat tariff basis (as applicable);

C. Accounts: shall be a simple accounting system confirming to Applicable Laws and accounting standards for recording all transactions of expenditure accounts, revenue accounts and capital accounts including debt service if any.

D. Operational Data – address all facets of the operation, maintenance and work order management, stores and inventory. Continuous logging of operational data like consumption of energy, chemicals and spares; volume of water produced, volume of water sold, treated water quality, repairs and bursts etc;

E. Asset Registry – shall be capable of recording all assets installed in the water supply scheme including the asset rehabilitation and replacements executed from time to time;

F. Record of units operated; power consumption and power factor at WS pumping stations, WTP on daily basis and monthly basis etc

G. Report Generation: Besides acting as a powerful standalone, report-creating application, reports shall provide a report-writing module that can add to applications. The report shall be generated in English. A multitude of ready-made reports for users to execute shall be incorporated. Users can modify and customize these reports or add new ones by using relevant reports. The Report Engine enables printing to a printer or

a preview window or the files can be exported through e-mail, directly to disk. The report can be exported in any of several word processing, spreadsheet, database file, or data exchange formats including HTML.

Operator's key responsibilities for MIS

i. The Operator shall be responsible for establishing, keeping and maintaining the information systems in conjunction with the Employer requirement. The Operator shall collect and keep up to date information on the above and below ground facilities.

ii. The Operator shall develop the MIS system architecture and on approval shall procure all the necessary hardware, software, network connectivity as required and install and commission the MIS system as indicted in SIP schedule.

iii. All facilities taken over by the Operator from employer and facilities created under the project shall be entered into the MIS. The Employer shall provide information in an agreed format.

iv. The Operator shall verify all information in accordance with procedures agreed with the Employer.

v. The Facility Register shall be supported by operational information on compliance with Performance Targets, achievement DMA wise.

vi. The Operator shall be responsible for operating the facilities in the correct manner and for maintaining them in a professional manner.

vii. The Operator shall use the data to plan the Annual O&M Plan in consultation with the Employer.

viii. The Employer shall be responsible for using the information to gain an overall view of the facility's value, performance and condition.

A. Facility Register

The Facility Register shall be a schedule (a computerized database, but also available on paper for ease of inspection) of all the facilities to be maintained under the responsibility of the Operator as agreed with the Employer. The Facility Register shall be used to perform, or support, the services carried out by the Operator.

The format of the Facility Register shall be designed in consultation with the Employer and/or Employer.

The Employer shall have the right to verify the Facility Register and the Operator's procedures for keeping it up to date.

B. Facility Numbering

Each above ground Facility shall be given a unique number within the Facility register. Numbering system shall be designed in consultation with the Employer. The number shall refer to the site and the type of Facility.

C. Performance and Condition Grades

Performance grades shall define whether the Facility is meeting the required quality standards or levels of service standards or is suitable for its function. Condition grades shall define the structural

condition of the Facility. This may be from an assessment of the structural condition or from recording of the frequency of failures of the Facility.

D. Records to be Produced and Maintained

The scope of the Facilities to be included is summarized in Table below.

Table 26: Scope of the Facilities

Type	Facilities	
Management and General	Stocks Computers and associated equipment Land Vehicles Plant	
	Above Ground	**Below Ground**
Supply Services	Pumping Machinery Reservoirs Pumping stations	Pipelines – Transmission and distribution mains Valves Service Connections Sewer lines (all) and house connections Storm water drainage lines

E. Operational Job Management

The Operator shall establish and maintain a suitable job management system, in consultation with the Employer. This job management system shall provide detailed information on Facilities such as the type and make of motors, pumps, equipment, valves maintenance schedules etc.

F. Record Drawings

Raw data on Facilities shall be held on Record Drawings.

The Operator shall establish and maintain up-to-date Record Drawings for both above ground and below ground Facilities.

The Operator shall update the Record Drawings and Facility Register to include the facilities taken over them, together with any works that are subsequently undertaken. The Record Drawings shall be updated by the Operator within 3 months of any modifications being carried out in the facilities.

G. Accuracy of Data.

The Operator shall assign 'Confidence Grades' to the data to validate its accuracy. The Operator shall develop the definitions of these grades and how they are to be used in consultation with the Employer.

H. Inventory Management

The Operator shall operationalise a computer based inventory management system to enable effective control of spares and consumables. This system shall use standard software and shall be linked by the Operator to MIS. The Operator shall provide monthly reports from this system to the Employer.

I. Customer Service Management System

Customer service encompasses a broad range of activities. The Customer Service Management System shall have an interface with the Customer's premises to ensure required performance are met (e.g. water pressure and flow) and proper response are given to customer enquiries. The following provisions shall be integrated into the customer service management system:

i. Advance warning of planned supply shut off for repairs and renewals

ii. Advice Customers during emergencies

iii. Billing Customers

iv. Dealing with billing queries

v. Recording and Responding to Customer Complaints

J. Systems and Procedures for Creating and Updating Customer Database

Within one year from the contract commencement date, Operator shall operationalise the Customer Database, with all customer contacts with respect to billing and provision of services can be controlled.

Information held shall include the Customer name, reference number, mailing address, telephone number and account history information.

LIST OF SPECIFIED MAKES

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
	PIPES	
1.	DI PIPES	JINDAL SAW/ TATA METALIKS/ KUBOTA/ELECTROSTEEL
2.	DI SPECIALS	JINDAL/BHARAT INDUSTRIAL CORPORATION/ ORIENTAL CASTINGS / ELECTRO STEEL CASTINGS/ TATA IRON AND STEEL CO./ KEJRIWAL CASTING
3.	HDPE/MDPE PIPES	JAIN IRRIGATION/ KIMPLAS/ TIMEPLAST,/DURALINE
4.	HDPE FITTINGS	KIMPLAS/GEORGE FISCHER/AVIVA/PRESTO
5.	uPVC PIPES	SUPREME/PRINCE/FINOLEX
6.	RCC PIPES	INDIAN HUME PIPES/ K K SPUN/JSP INFRA
7.	DISMANTLING JOINTS	BHARAT INDUSTRIAL CORPORATION /ORIENTAL CASTINGS / ELECTRO STEEL CASTINGS / TATA IRON & STEEL CO/KEJRIWAL CASTING
	PUMPS	
8.	CENTRIFUGAL WATER PUMP SETS	KIRLOSKAR/ JYOTI/ M&P (WILO) / FBM(PENTAIR)/ AQUA/ WPIL/ KSB /FLOWMORE
9.	SUBMERSIBLE PUMP SET	KIRLOSKAR / CROMPTON GREAVES/ SIEMENS/ KSB/ VOLTAS / AQUA/ WPIL
10.	VACUUM PUMP	KIRLOSKAR / SLM MANEK LAL
11.	POSITIVE DISPLACEMENT	TUSHACO / NETZSCH / ROTO PUMPS
12.	DOSE METERING PUMPS	ASIALMI/SWELLORF/VK/SR
	VALVES & GATES	
13.	DI RESILIENT (SOFT) SEATED SLUICE VALVE	FOURESS/ IVC/ KIRLOSKAR/ CALSENS/ VAG/ /DURGA /AVK
14.	BUTTERFLY VALVE	FOURESS/ IVC/ KIRLOSKAR/ CALSENS/ VAG/ /DURGA /ADVANCE /AVK
15.	NON RETURN VALVE	FOURESS/ IVC/ KIRLOSKAR/ CALSENS/ VAG/ /DURGA /ADVANCE /AVK
16.	AIR VALVE	FOURESS/ IVC/ KIRLOSKAR/ CALSENS/ VAG/ /DURGA /ADVANCE /AVK
17.	SELF-REGULATING PRESSURE	FORBES MARSHALL/ INSTRUMENTATION LTD./ KEYSTONE

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
18.	SOLENOID VALVE	ASCO/ AVCON/ HERION, ROTEX/ JUCOMATIC/ SCHRADER-SCHOVILL
19.	SLUICE GATES	JASH ENGINEERING (P) LTD. / THE INDIAN VALVE CO. /ORIENTAL CASTINGS
	MOTOR & ACTUATORS	
20.	SQUIRREL CAGE INDUCTION MOTOR	KIRLOSKAR (KEC) /JYOTI / SIEMENS/ CGL/ BHEL/ NGEF/ BHARAT BIJLEE/
21.	ELECTRICAL ACTUATORS	AUMA/ MARSH/ ROTORK/ SIEMENS/EMTORK
	INSTRUMENTS	
22.	ELECTROMAGNETIC FLOW METER	ABB/ SIEMENS/ ENDRESS & HOUSER/FORBES MARSHAL
23.	ULTRASONIC FLOW METER	SIEMENS/ ENDRESS & HOUSER/FORBES MARSHAL/HONEYWELL
24.	LEVEL (ULTRASONIC TYPE) TRANSMITTER	ABB /VEGA INSTRUMENT/ ENDRESS & HAUSER/ EMERSON (ROSEMOUNT)/ KROHNE MARSHALL/ SIEMENS / HONEYWELL/ YOKOGAWA
25.	LEVEL SWITCH	VEGA INSTRUMENT/ ENDRESS & HAUSER/ KROHNE MARSHALL/ABB/ EMERSON (ROSEMOUNT)/ HONEYWELL
26.	LEVEL SENSORS (CAPACITANCE TYPE)	LEVCON/TOSHNIWAL/PUNE TECHTROL/E&H/RLT
27.	LIMIT SWITCHES	BHARTIA CUTLER HAMMER/ ELECTROMAG/ ELECTRONIC & POWER CONTROL COMPANY/ HONEYWELL AUTOMATION (I) LTD/ L & T/ SIEMENS AG/ SPEED O CONTROLS PVT LTD
28.	FLOW SWITCH	KROHNE-MARSHALL / SIEMENS AG/ SWITZER/ LEVCON
29.	ORP / PH / CONDUCTIVITY MEASUREMENT	ABB/ FORBES MARSHALL / SIEMENS / YOKOGAWA/ HONEYWELL/ AMETEK/ EMERSON/ E&H/HACH
30.	TURBIDITY MEASUREMENT	ABB/ E&H/ GE INSTRUMENTATION/YIL / FORBES MARSHAL/ EMERSON/HACH
31.	PRESSURE / DIFFERENTIAL PRESSURE	AN INSTRUMENTS/ GENERAL INSTRUMENTS/ KSB / WAAREE INSTRUMENTS/ SIEMENS / MANOMETER INDIA/ FORBES MARSHALL
32.	PRESSURE / DIFFERENTIAL PRESSURE TRANSMITTER	ABB/ CHEMTROLS / EMERSON (ROSEMOUNT)/ HONEYWELL/ KSB / SIEMENS / YOKOGAWA/ FORBES MARSHALL/E&H
33.	PRESSURE RELIEF VALVE	TYCO SANMAR/ KSB AG/ KEYSTONE VALVES LTD./ SEBIM VALVES

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
34.	CHLORINE MEASUREMENT	ABB/E&H/ CHEMTRAC/ PROMINENT FORBES MARSHALL/YIL/HACH/EMERSON
	MECHANICAL EQUIPMENT	
35.	CRANE & HOIST	HERCULES, ELECTROMECH, EDDY CRANES, W H BRADY/REWA/ACME
36.	AIR COMPRESSOR	KIRLOSKAR PNEUMATICS/ELGI/ ATLAS COPCO/ INGERSOLL-RAND
37.	CHLORINATORS	METITO / PENWALT / CHLOROCONTROL / INDUSTRIAL DEVICE
38.	CLARIFIER / CLARIFLOCCULA	HINDUSTAN DORR-OLIVER / GEO- MILLER / EMCO KCP / TRIVENI ENGINEERING / VOLTAS
39.	PP NOZZLES	GUDDI PLASTCON / N.K INDUSTRIES / B K INDUSTRIES
40.	CENTRIFUGE	ALFA LAVAL INDIA LTD., / PENNWALT LTD., / HUMBOLDT WEDAG / HILLER
41.	AGITATORS / MIXERS	REMI / MILTON ROY /FIBRE & FIBRE / EMICO / GEOMILLER / TRIVENI/PARAMOUNT
42.	FILTER MEDIA SAND / GRAVEL / ANTHRACITE	GLOBAL ADSORBENT / AP INDUSTRIES / AQUA ZONE / CENTRAL AGENCY
43.	AIR BLOWER	EVEREST/KAY INTERNATIONAL/USHA/ACME/SWAM
44.	SURGE CONTROL DEVICES (ZERO VELOCITY VALVE)	SURESEAL/MEGHA ENGINEERING/FLOWNIX/MANNEMANN MEER
	ELECTRICAL	
45.	TRANSFORMER	BHARAT BIJLEE/ KIRLOSKAR / ABB/ BHEL/ ALSTOM/ /VOLTAMP/BHEL/CGL
46.	CURRENT TRANSFORMER AND POTENTIAL	AUTOMATIC ELECTRICAL / KAPPA / BHEL / ABB/JYOTI
47.	POWER CAPACITORS	CROMPTON GREAVES LTD. / L&T, SCHNEIDER /EPCOS / BCH/UNISTAR/ KHATAU
48.	INSULATORS	BHEL / JAI SHREE / WSI
49.	PROTECTIVE RELAYS / RELAY	ALSTOM / SIEMENS / ABB / SCHNEIDER/ LARSEN & TOUBRO
50.	DC BATTERIES / POWER PACK	EXIDE / STANDARD BATTERIES LTD. / AMCO BATTERIES LTD. / FUKUWA
51.	BATTERY CHARGERS	EXIDE / AMCO/UPTRON/ AE /HBL/ EXPO / LOBOTEK / ROTROMIX / BCH
52.	H.T., L.T. CABLES	CABLE CORPORATION OF INDIA / UNISTAR/ RPG / KEI / POLYCAB/HAVELLS/ INDIAN CABLE CO.
53.	CONTROL CABLE	CABLE CORPORATION OF INDIA / UNIVERSAL / RPG / KEI / FINOLEX/POLYCAB/

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
54.	LIGHTING CABLES	RPG /KEI / FINOLEX /HAVELLS/POLYCAB
55.	LIGHTING FIXTURES	PHILLIPS / GEC / BAJAJ ELECTRICAL LTD. / CROMPTON GREAVES LTD. / WIPRO LTD. / HAVELLS
56.	H.T. & L.T. TERMINATION	RAYCHEM / CCI / M-SEAL
57.	LIGHT POLES	BAJAJ / VALMONT / SUMIP
58.	SMART ENERGY METERS	ABB / SCHNEIDER / L&T / SECURE METERS
59.	AUTOMATIC POWER FACTOR	CROMPTON / LARSEN & TOUBRO LTD. / C&S / BCH
60.	LT SOFT STARTER	SIEMENS / ABB / DANFOSS / SCHNEIDER ELEC. PVT. LTD. INNOVATIVE TECH. (P) LTD. /JAYASHREE
61.	HV AND LV BUSHINGS	BHEL / JAYSHREE / WSI / CGL / SSB
62.	CABLE GLANDS	HMI / GRIPWEL / COMET
63.	CABLE LUGS	DOWELLS / AMP (TYCO ELECTRONICS)
64.	ANNUNICATORS	MINILEC/APLAB/LETROTEK/MASIBUS
65.	SEMAPHORE	ALSTOM / ABB / SIEMENS / SCHNEIDER
66.	MODULAR TYPE SWITCHES	NORTH WEST / MK / MDS / SCHNEIDER / LEGRAND
67.	INDICATING METERS	AE/ SCHNEIDER/ABB
68.	PUSHING BUTTON &	L&T / BCH / SIEMENS / C&S
69.	SELECTOR & CONTROL	ALSTOM / SIEMENS
70.	MCCB / MCB	SIEMENS / ABB / SCHNEIDER /MDS / LARSEN & TOUBRO / C&S / HAVELLS
71.	SWITCH SOCKETS &	BCH / MDS / CROMPTON / SCHNEIDER
72.	MCB DISTRIBUTION	MDS / SIEMENS / ALSTOM / SCHNEIDER
73.	LIGHTING PANELS	MDS / SIEMENS / L&T / SCHNEIDER
74.	INDICATING LAMPS	SIEMENS / BCH / TECNIC / SCHNEIDER
75.	CONTACTORS	L&T / SIEMENS / ALSTOM / SCHNEIDER
76.	PORTABLE FIRE EXTINGUISHERS	MINIMAX / MATHER PLATT / CEASFIRE

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
77.	SCADA INCLUDING	ALSTOM / SCHNEIDER / ABB / SIEMENS / HONEYWELL/ L&T / MITSUBISHI/FORBES MARSHALL
78.	ON LINE UPS, SERVO STABILIZER,	AEI/ BHEL/ HIND RECTIFIER/ L&T/ NGEF/SIEMENS/ HI-REL/ AUTOMETER/ ENERTECH/ PYRAMID/ APC/DUBAS/ LUMINOUS/ MICROTECH/TATA LIBERT
79.	LIGHTING ARRESTERS	ELPRO / ABB / BHEL/ OBLUM/IGE
80.	VACCUM CIRCUIT BREAKER (INDOOR & OUTDOOR)	ABB/ ALSTOM / AREVA/ SIEMENS/BHEL/CGL/SCHNEIDER
81.	HRC FUSES	L&T/ /ABB/CROMPTON GREAVES/GE/C&S/ SIEMENS/ HAVELLS/ SCHNEIDER
82.	ALTERNATORS	KEC/JYOTI/AVK/CROMPTON
83.	LT / HT SWITCHGEAR PANEL	SCHNEIDER/L&T/SIEMENS/ABB/C&S/CGL
84.	MEASURING INSTRUMENTS, AMMETER,	SIMCO/ IMP/ AUTOMATIC/ GEC / MECO /AE/ CONSERVE/ L&T/ SIEMENS /INDUSTRIAL METERS
85.	SELECTOR SWITCHES, ROTARY SWITCHES	SIMCO/ IMP/ AUTOMATIC/ GEC/ MECO/ AE/ CONSERVE / L&T/SIEMENS /INDUSTRIAL METERS
86.	EXHAUST FAN/ CEILING FAN/ AIR CIRCULATOR/ PEDESTAL FAN/ BRACKET FAN	CROMPTON GREAVES/ USHA/ ORIENT/ GEC/ ALMONARD/ KHAITAN/ HAVELLS/ BAJAJ/ PHILIPS / POLAR/ ANCHOR
87.	AC UNITS / CENTRAL ACS	HITACHI / LG/ SAMSUNG/ VOLTAS/ BLUE STAR/ CARRIER / GODREJ/ VIDEOCON/ MITSUBHISI /LLOYED
88.	SOFT STARTERS	ABB/ CGL/ SCHNEIDER/ SIEMENS AG
89.	VARIABLE FREQUENCY (SPEED) DRIVES	ABB/ LARSEN & TOUBRO/ SIEMENS AG
	CONTROL & INSTRUMENTATION	
90.	AUXILIARY RELAYS	OEN/ SIEMENS
91.	CABLE GLANDS	COMET/ DOWELL'S ELEKTRO WERKE/ GLAND MECH INDUSTRIES

SR.NO.	ITEM/EQUIPMENT	SPECIFIED MAKES
92.	CABLE TRAYS – FRP / GRP	DENSONS/ ERCON/ GENERAL COMPOSITES/ INDIANA/ PREMIER/ SUMIP
93.	CONTROL DESK, I/O PANELS& PLC PANELS / CONSOLES	CHEMIN/ INSTRUMENTATION LIMITED/ SIEMENS / LOTUS/FORBES MARSHAL/ ABB/ MITSUBISHI/SCHNEIDER
94.	DC POWER SUPPLY UNIT	APLAB/ SIEMENS AG/ SCHNEIDER/ PHOENIX
95.	FIBER OPTIC CABLES	AMP/ KRONE/ MOLEX
96.	INSTRUMENT PANELS	INSTRUMENTATION LTD/ PYROTECH/ RITTAL
97.	INSTRUMENT TUBING	APEX TUBES PVT LTD./ CHOKSY TUBE CO LTD./ MAHARASHTRA SEAMLESS LTD./ RATNAMANI METAL & TUBES
98.	PLANT CONTROL SYSTEM / SCADA	ABB/ EMERSON (ROSEMOUNT)/ HONEYWELL/L&T/ ROCKWELL AUTOMATION/ SCHNEIDER/ FORBES MARSHALL/ SIEMENS / MITSUBISHI/E&H
	OTHERS	
99.	DG SET (ALTERNATOR)	CROMPTON GREAVES / KIRLOSKAR GREEN/ STAMPFORD / KEC/ LEROY SOMER
100.	DG SET (ENGINE)	CUMMINS/ KIRLOSKAR GREEN/ CATERPILLAR/ PENTA VOLVO /ASHOK LEYLAND /MAHINDRA & MAHINDRA/ PERKINS
101.	REINFORCEMENT STEEL	SAIL, VIZAG STEEL, TATA
102.	CEMENT	ACC, AMBUJA, LAFARGE, ULTATECH
103.	AMR WATER METERS	ITRON, ARAD, BAYLAN